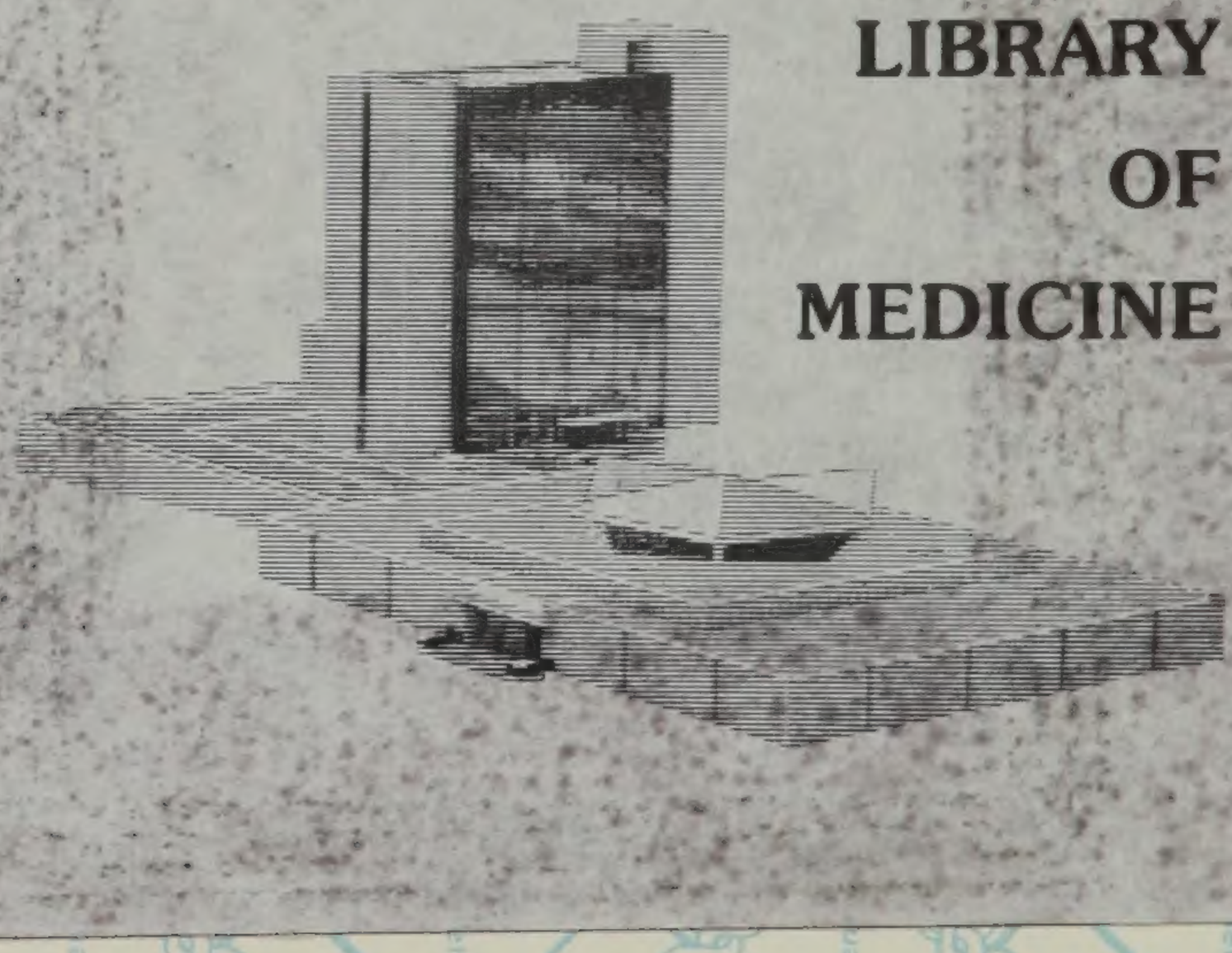
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SURGERY OF THE LUNG

The Oration in Surgery Delivered at the Forty-ninth Annual Meeting of the American Medical Association, held at Denver, Colo., June 7-10, 1898.

BY J. B. MURPHY, M.D.
CHICAGO, ILL.

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SURGERY OF THE LUNG.

BY J. B. MURPHY, M.D.

Mr. President and Members of the American Medical Association:—Permit me to express my appreciation of the great honor conferred on me when elected to deliver the Annual Address on Surgery to this distinguished body of scientists. Custom has ordained that the address in the specialties of medicine at our annual convocation should be confined to a review of the advancements of the science and art of this branch in general in the preceding year. I take the liberty of deviating a little from this precedent to review the efforts and achievements made in a special and, until the last two decades, neglected field of surgery. I believe I am justified in this digression, as at the last, our semi-centennial convention, my predecessor enumerated and so emphasized the achievements of surgery for the last half century that I fear the consideration of a year's progress would be of small interest.

I have therefore chosen for my subject today the surgery of the lung. An analysis of the accomplishments in this special line of work is of great interest, the advancements having been made by individual and unsupported efforts. The profession at large has never entered into this field with the enthusiasm, persistency and energy with which it has invaded other fields, as the peritoneum, the genito-urinary, the osseous and nervous systems. Indeed, if we were to take from the list of original investigators and operators in this field thirty names, it would be practically a blank; the work has been of a desultory character. The surgery of the lung has had its epochs of advancement. In no field of medicine has the intermittence in surgical effort been so conspicu-

ous as in that of the lung. We find that Hippocrates, in the fourth century, B. C., recognized that pneumonic abscesses opened into the bronchus and slowly recovered in that way. He repeatedly opened them through the chest wall and resected the rib to obtain a better field. He advised thoracotomy and pneumotomy as the proper treatment for this class of cases[1]. These operations were then lost sight of and did not come to light again until 1584, when Schenk[2] recommended them. Oblivion was its fate again until Willis in 1664 drew attention to it. Bligney in 1670 reported a case of phthisis which was cured by accidental puncture of the chest with a sword; the opening allowed the pus to escape from the lung. Purmann in 1692 advised incision of the chest wall in hemorrhage, empyema and pulmonary cavities, and for removal of all kinds of effusions. Baglini in 1696 opened the chest. Baglivus in 1710 treated wounds of the lung by free incision of pleura and advised the same treatment for phthisical cavities. Berry of Dublin, in 1726, suggested the drainage of pulmonary cavities, and cited cases of recovery following pulmonary incision. Sharpe in 1769 dwelt on the difficulties of separating pleuritic adhesions and advised cutting into the cavity with the lance and inserting tubular drainage.[3] Pouteau and David in 1783 advised incision to pleura and trocar to depth of pus.[4] Faye in 1797 operated for abscess of the lung which was adherent, and advised puncture, irrigation and tampon; for such cases Jaymes and Richerand in 1813 advised incision.[5] H. Callisen in 1815 advised puncture and exploration of the chest by paracentesis, and if pus were detected, incision of the pleura; then digital palpation for fluctuation in the lung with immediate incision.[6] Zang in 1818 reported fifteen incisions of the chest wall, seven for empyema and eight for abscess. Nasse in 1824 incised a pulmonary cavity.[7] Krimer in 1830 wished to perform this

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1 Ed. Littré, Vol. vii, p. 61.
2 Wm. Koch, History of Lung Surgery.
3 Treatise of Operation in Surgery, London, 1769, p. 128.
4 Mém. Surg., la Thesie Pulmonaire, Paris, 1783.
5 Jour. Gen. Med., Vol. xlv.
6 Callisen's System of Surgery. Ed. iv, Vol. i, 1815. p. 413.
7 Harris' Arch. für Med. Erf., Band ii, Seite 117.

operation, but the medical consultant would not consent. Brichatan in 1830 opened a cavity with a caustic paste and also one with the scalpel, in which he cut into the lung a distance of eight lines and then dilated with forceps. The latter patient lived nine

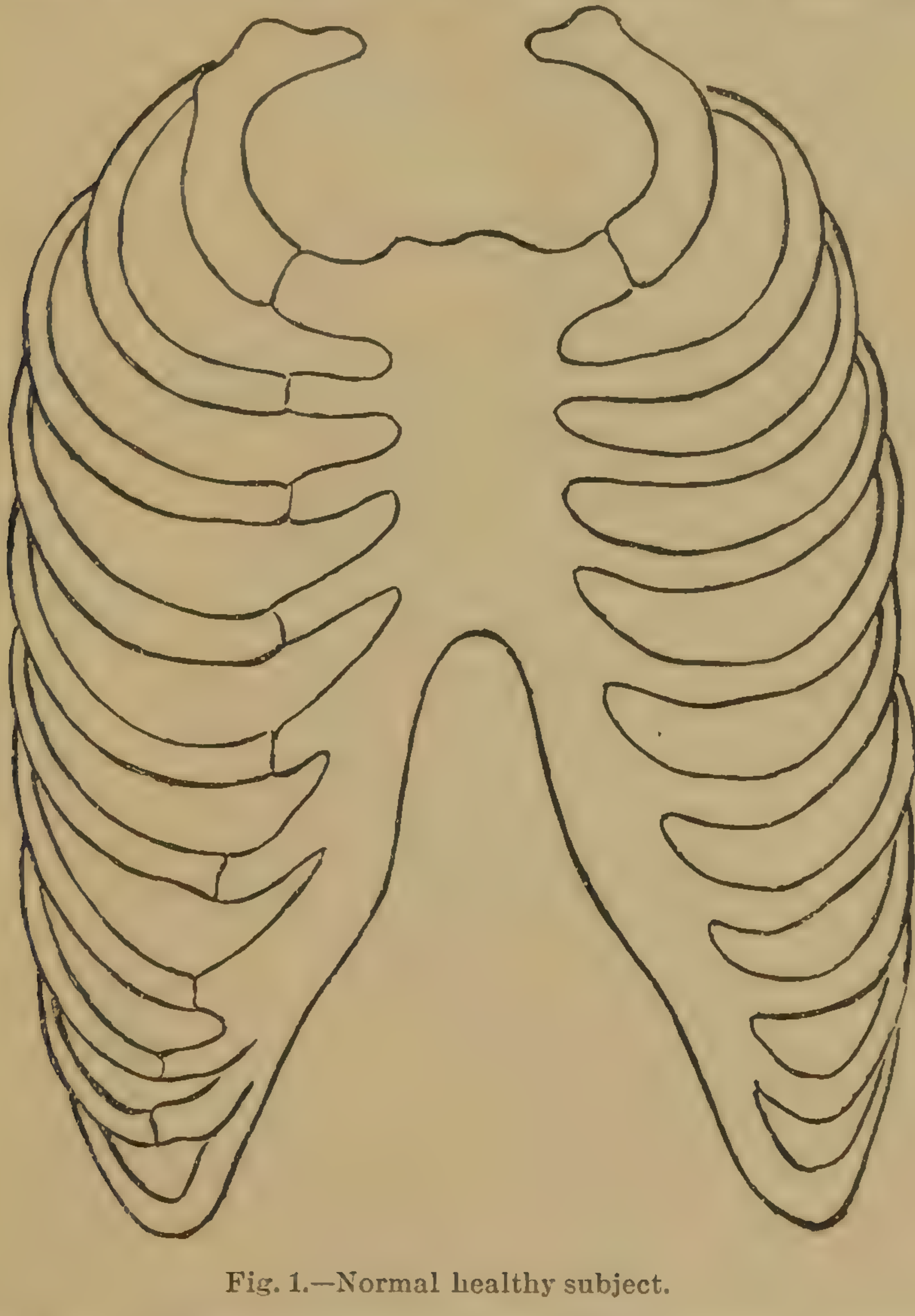


Fig. 1.—Normal healthy subject.

months. Postmortem showed the cavity obliterated.[8] To the above list of investigators may be added the names of Brichet, 1831; McLeod, 1836; Clausen, 1839; Hastings, Herf and Collins, 1844. Then came a long period of quiescence until we find

[8] Jour. Comp. des Sc. Méd., No. 36, p. 144, 1830.

the subject again receiving attention as a modern advancement in 1873 by Mosler and Pepper.[9] Neisler, 1873, drained a tubercular cavity of the lung. The work of F. Mosler is conspicuous as he, though a medical man, advocated in repeated theses surgical interference in diseases of the chest. His efforts were ably supported by Koch and Bull, and the experiments of Gluck, Block, Hans Schmid, D. Biondi, and by the cases of Rugge, Christian Fenger, E. W. Andrews, Kroenlein, Omboni, Roswell Park, B. Pitts, Fabricant and others.

It would be impracticable for me to enumerate here the names of men who have labored so zealously in the interest of surgery of the lung, as they will be given due credit under the special headings to which their investigations contributed. Let us consider, first, the anatomy; second, the physiology; third, the experimental research, and fourth, the course and results in clinical cases. The last two we will take up under the headings of separate operations or pathologic conditions, while the first two, the anatomy and physiology, will be treated of here.

Anatomy.—The lungs are almost entirely situated within the bony cavity of the chest, the exception being the small projection of the apices above the level of the first rib. A straight line drawn, however, from the upper surface of the first rib behind to the upper surface of the clavicle in front, would pass above the apices. A straight line drawn in any position from the margin of the ribs and costal cartilages or sternum across the chest cavity below would not touch the lung. The chest has two diaphragms, the first closing a small kidney-shaped orifice, made up by the combined arches of the first ribs, the sternum in front and the spine behind. The large vessels of the neck, the trachea, esophagus and nerves pass through this orifice. This diaphragm rises and falls with each respiratory act, from one-half to one and one-half inches in extent, depending upon the respiratory effort and the condition of the respiratory organs, moving most in health and least, if at all, in apical disease. The chest, from its upper diaphragm, in its

[9] Deut. Med. Woch., 1882.

normal shape represents a continuous conical expansion to the lower margin of the ribs. (See Fig. 1.) The dress in females converts it into a balloon shape; the same is true of emphysema; the most expanded portion of the chest, under these circumstances, is

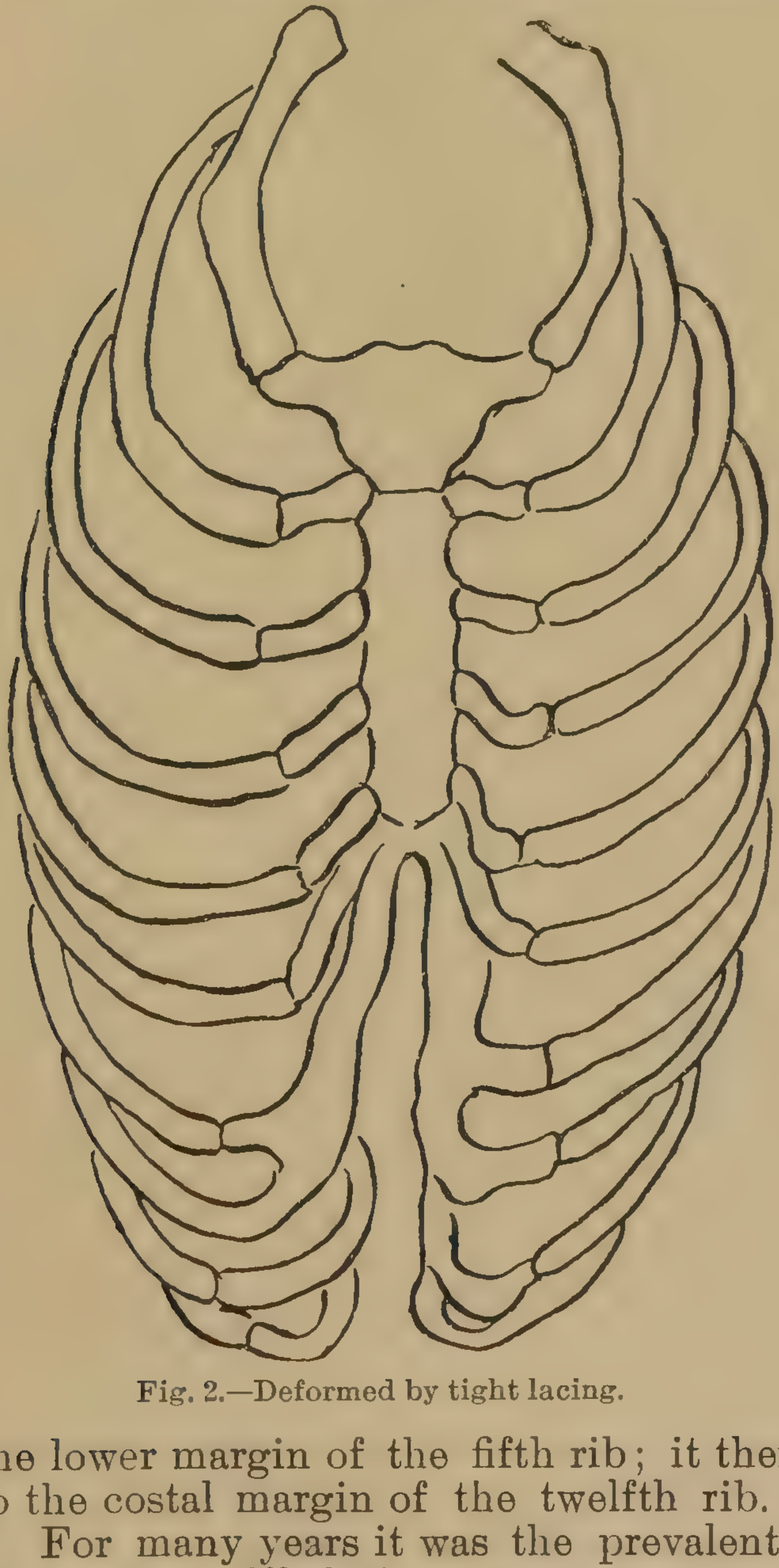


Fig. 2.—Deformed by tight lacing.

about the lower margin of the fifth rib; it then contracts to the costal margin of the twelfth rib. (See Fig. 2.) For many years it was the prevalent opinion that the lung filled the greater portion of the chest. The modern anatomist has demonstrated on

frozen specimens that only a small portion of this cavity is occupied by the lung. The radiographs which I have had made show that the position of the diaphragm in the frozen specimen and cadaver is misleading. (See Figs. 3 and 4.)

The space embraced within the chest is filled in behind, first, by the anterior curvature of the heads and necks of the ribs and the bodies of the dorsal vertebræ; the spinal column extending far forward helps to make up the mediastinal septum, which divides the chest into two irregular flattened cones. The distance from the sternum to the spine is about two-thirds of the depth of the thickest portion of the cone, which is from the most prominent posterior part of the arc of the rib directly forward (as shown in Figs. 5 and 6 from Fowler and Godlee).

The hilum of the lung resting anterior to the spine is therefore about midway between the anterior and posterior margins of the chest cavity as outlined by the ribs. The anomalies of the ribs and the shape of the chest change the respective relations between portions of the lung and chest wall, and must be considered in the surgery of the individual case. When a seventh cervical rib is present it extends far above the level of the apex of the lung and may compress it, but it is not so likely to interfere with the lung as with the roots of the brachial plexus. An additional dorsal rib is usually accompanied by an elongation of the pleural cavity at that point, but the lung does not fill the pleura to its margin. A bifurcation of the ribs anteriorly has no particular influence upon the chest. The seventh is usually the last true rib; the eighth, however, is occasionally joined to the sternum. The width of the intercostal spaces is of importance; it is greatest in the second and third and tenth and eleventh, and is widest just at the tip of the bony end; it can be increased to its greatest degree when the spine is erect, but is not necesarily increased on inspiration. A division of the pectoral and intercostal muscles allows of a great increase in the separation of the ribs; this is most marked in the young. The space in children attained in this manner usually suffices for operation without costal resection.

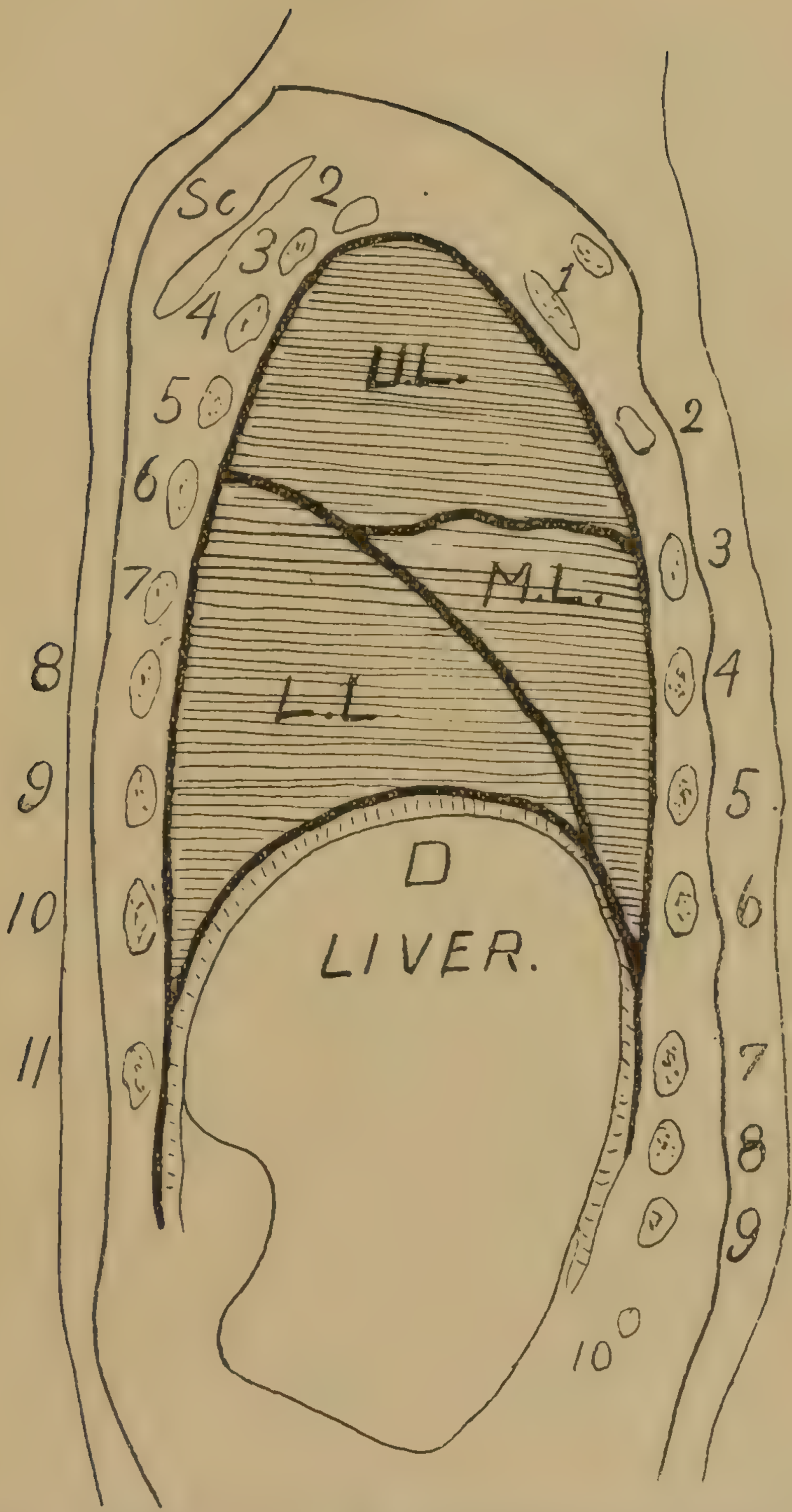


Fig. 3.—Sagittal section (right) after Rüdinger. Cl, clavicle; Sc, scapula; D, diaphragm; U.L., upper lobe of lung; M.L., middle lobe of lung; L.L., lower lobe of lung. The pleura is indicated by heavy lines.

The sternum is not perpendicular; it deviates from this about 25 degrees. Its angle ranges in the respiratory act between the 160th and the 170th degrees. (Fowler and Godlee.)

The diaphragm forms the lower elastic, irregularly convex boundary of the chest. It is a very large-sized muscle with firm attachments to the entire circumference of the lower margin of the chest. It is in constant movement in health, and is the most powerful individual respiratory muscle. It is the piston of respiration; the chest wall is the cylinder. See Figs. 7 and 8. Its vaulting within the chest cavity is of the utmost import to the physician and surgeon. It is divided into two almost equal parts; the central and front part, corresponding to the position of the heart, is the highest and is practically stationary. It is on a level with the fourth interspace on the right side, with the sixth rib in the axillary line and with the eighth rib in the scapular line and the body of the ninth dorsal vertebra. On the left side at the points mentioned it is five-eighths of an inch lower. In health it varies from the third to the sixth interspaces in its vaulting. (See Figs. 7 and 8.) The origin of the central (spinal) portion is fixed, and its vaulting is changed by the contraction and relaxation of the diaphragmatic muscle assisted by the intra-abdominal pressure. The arch and length of the diaphragm are changed by the shape of the chest; it is shorter and higher arched in the hollow-shaped chest of females and emphysemata. In the balloon-shaped chest the diaphragm has the least action; this shape is considered a predisposing cause to phthisis. The degree of the vaulting of the diaphragm into the chest in life has been overestimated by anatomists from the examination made by them on the cadaver and frozen specimens; a study of my radiographs, a few of which are here reproduced, will show that the diaphragm in forced expiration elevates to a level with the lower margin of the fifth rib in the extreme and usually only to the sixth rib. In forced inspiration it is an inch to an inch and a half lower.

It will be seen in radiograph No. 1, which was taken in full inspiration, held for seventy seconds

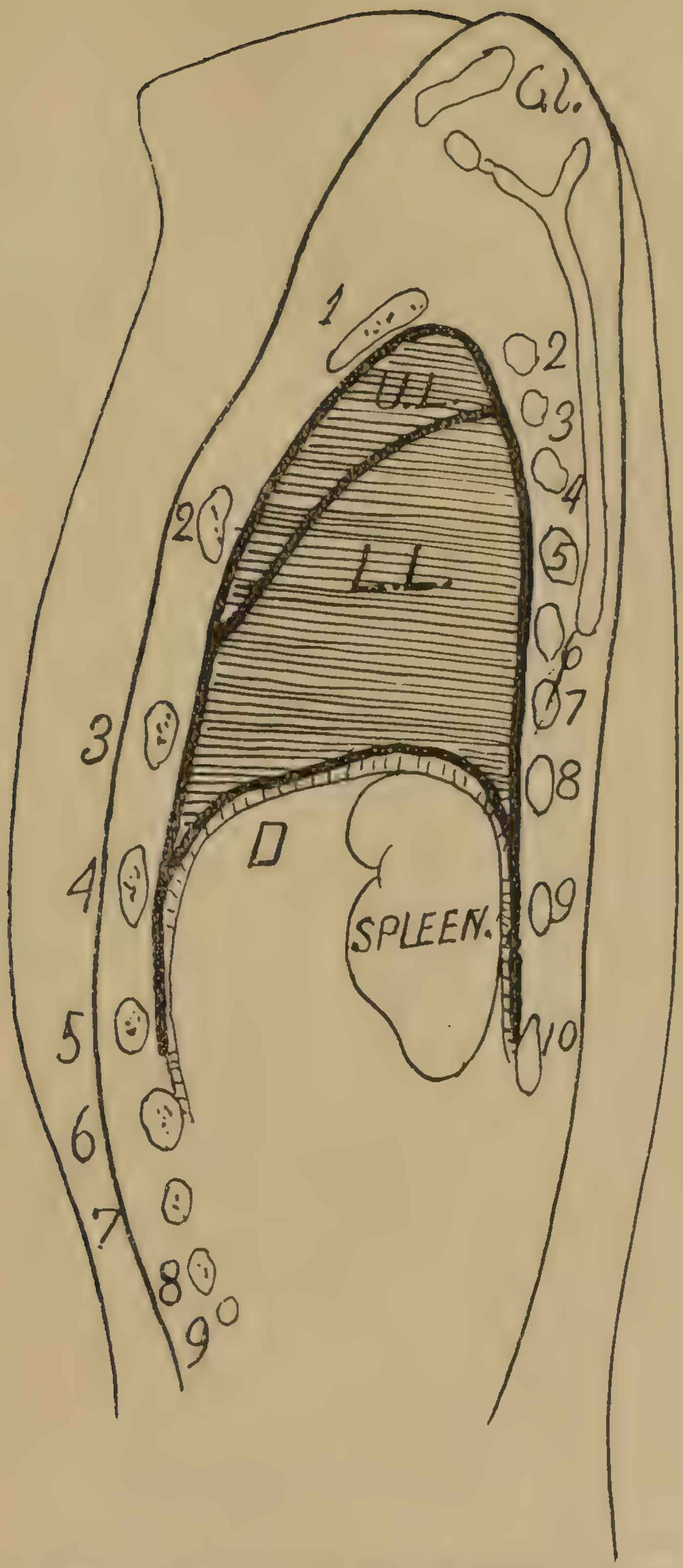


Fig. 4.—Sagittal section (left) after Rüdinger. Cl, clavicle; Sc, scapula; D, diaphragm; U.L., upper lobe of lung; L.L., lower lobe of lung. The pleura is indicated by heavy lines.

during the entire exposure, that the diaphragm on the right side comes to a level with the middle of the seventh rib at its cartilaginous junction; on the left side that it is about three-eighths of an inch lower and passes to the margin of the ribs with a lesser vault.

Radiograph No. 2 shows that in complete expiration, held for forty seconds during the entire exposure in the same healthy individual, the highest portion of the diaphragm came to the upper margin of the sixth rib on the right side and was about one-fourth inch lower on the left. This shows the degree of movement of the diaphragm in the respiratory act.

Radiograph No. 3, from a male adult, exposure forty-five seconds, shows in complete retained inspiration that the diaphragm on the right side comes to the middle of the sixth interspace, and on the left side it extends about three-eighths inch higher. Radiograph No. 4, from same person as No. 3, shows the position of the diaphragm during complete exposure of forty-five seconds in extreme expiration; the diaphragm on the right side comes to a level with the lower margin of the fifth rib, and on the left side it extends about one-third of an inch lower.

Radiograph No. 5, Miss K., emaciated female, shows the diaphragm on the right side as taken during normal respiratory movements, face down; it extends to the lower margin of the fifth rib; the outline is not discernible on the left side. Radiograph No. 6, back down; Miss K., the same individual as radiograph No. 5, shows the diaphragm on the right side as taken during normal respiration; it extends to a level with the upper margin of the fifth rib in front and on a level with the middle of the tenth rib behind; the diaphragm on the left side is one-fourth inch lower. Radiograph No. 7, Miss K., showed the same result. The results in an additional number of radiographs not here reproduced have been practically the same.

The *chest wall* is supplied with blood by the intercostal arteries; the first branch is given off from the subclavian and the others from the posterior surface of the aorta. They are close to the pleura behind and separated from it with the accompanying veins in

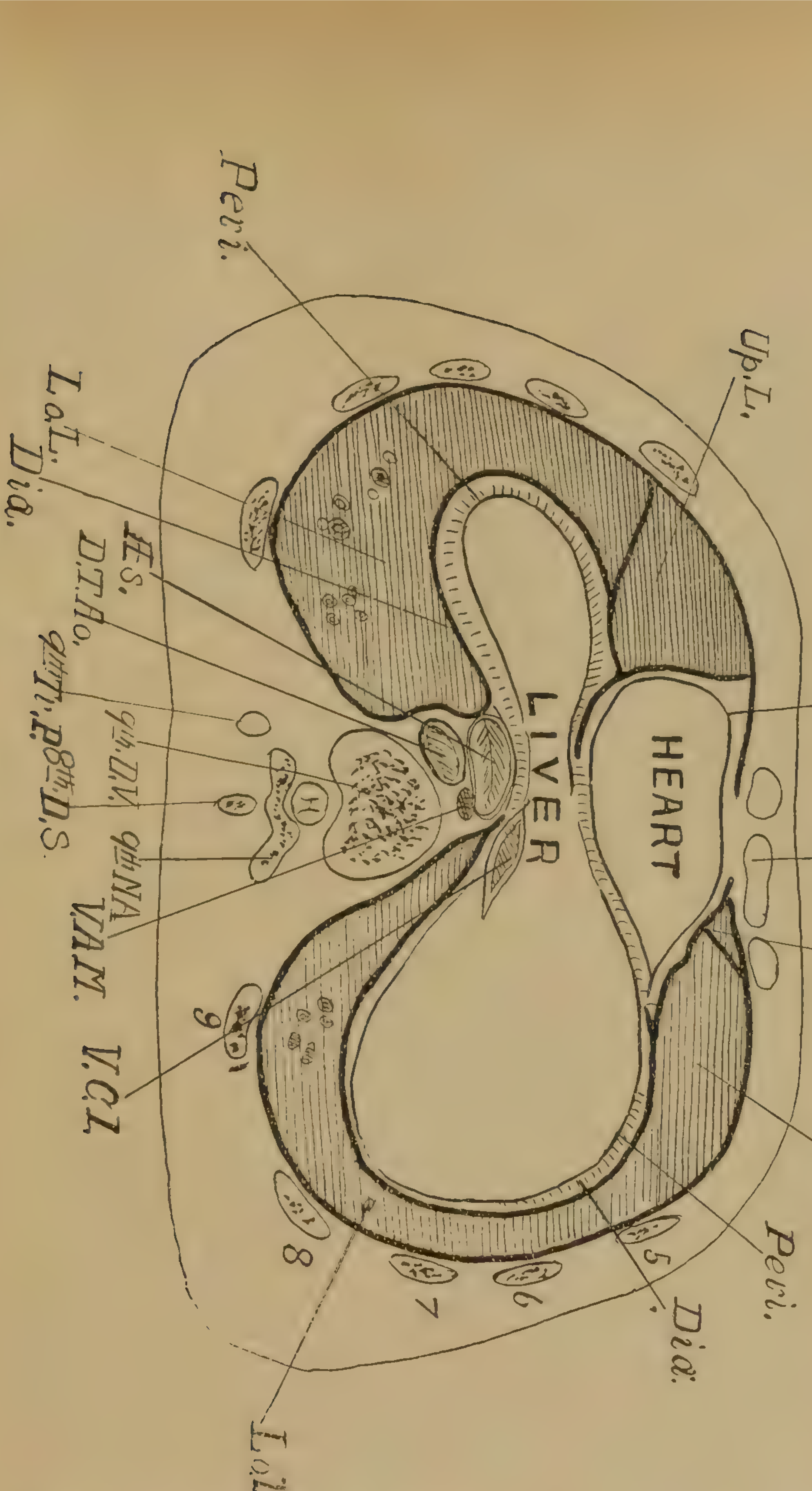


Fig. 5.—Through ninth dorsal vertebra. 9th D.V., ninth dorsal vertebra; 9th N.A., ninth natural arch; 9th Tr. P., ninth transverse process; 8th D.S., eighth dorsal spine; St., sternum; 5, 6, 7, 8, 9, ribs and cartilages; D.T.Ao., descending thoracic aorta; V.C.I., vena cava inferior; V.A.M., vena azygos major; Æs., æsophagus; Dia., diaphragm; P., pericardium; Up.L., upper lobes of lungs; Lo.L., lower lobes of lungs; Mid.L., middle lobe of right lung. The pleura is indicated by heavy line.

front by the intercostal muscles. In addition the chest wall receives a blood supply from the internal mammary artery, which runs down behind the sterno-clavicular articulation, along the posterior surface of the rib cartilages about one-half inch from the sternum. At the sixth space it subdivides into the superior epigastric and musculo-phrenic; it gives off small intercostal branches in its course. An anomaly of this artery, an early subdivision at the second or third space, may occur and a large branch extend outward and downward in the direction of the nipple. This branch would be interfered with in most operations through the anterior wall of the chest. In operations on and accidents to the anterior chest wall the location of the internal mammary artery should be distinctly borne in mind, as fatal hemorrhage has occurred from incisions, or injuries to this artery. The intercostal veins empty into the azygos and superior intercostal veins. The azygos veins are large and flat and have scarcely a plus pressure. In separating the adhesions of a diseased apex on the mediastinal side the azygos must be given great consideration, as it is easily torn and has a double danger, hemorrhage and air embolus; the azygos completely collapsed in the dog with each inspiratory act. (See Fig. 9, azygos vein and internal mammary artery.)

Lymphatics.—The lymphatics of the chest wall connect with the intercostal glands situated at the costo-vertebral junction. The efferent vessels from these glands empty into the thoracic duct, their lower branches into the receptaculum chyli. In front they run forward with the internal mammary artery and vein, where they have additional glands (sternal). The substernal glands also receive lymphatics from the anterior abdominal wall, diaphragm and liver. This anatomic feature explains the secondary mediastinal infections and tumors which occur from diseased foci at and below the diaphragm.

The mediastinum is best studied with the classification of Quain: the superior mediastinum, is that above a line drawn on a level with the upper border of the pericardium from the lower portion of the fourth dorsal vertebra behind to the junction of the



Fig. 6.—Through eighth dorsal vertebra. 8th D.V., eighth dorsal vertebra; 7th D.S., seventh dorsal spine; Sc., scapula; St., sternum; D.Ao., descending thoracic aorta. V.A.M., vena azygos major; Æs., æsophagus; P., pericardium; Up.L., upper lobe of lungs; L.L., lower lobe of lungs; Mid.L., middle lobe of right lung. The pleura is indicated by heavy lines.

manubrium with the body of the sternum in front. It contains the trachea, esophagus, thoracic duct, the arch of the aorta, the innominate, left common carotid and subclavian arteries, innominate veins and the upper part of the superior vena cava, the phrenic and pneumostric nerves, the left recurrent and cardiac nerves, the cardiac lymphatics and the remains of the thymus gland. The anterior mediastinum is the narrow upper half; the two pleuræ come in contact in this position, and occasionally have a communicating

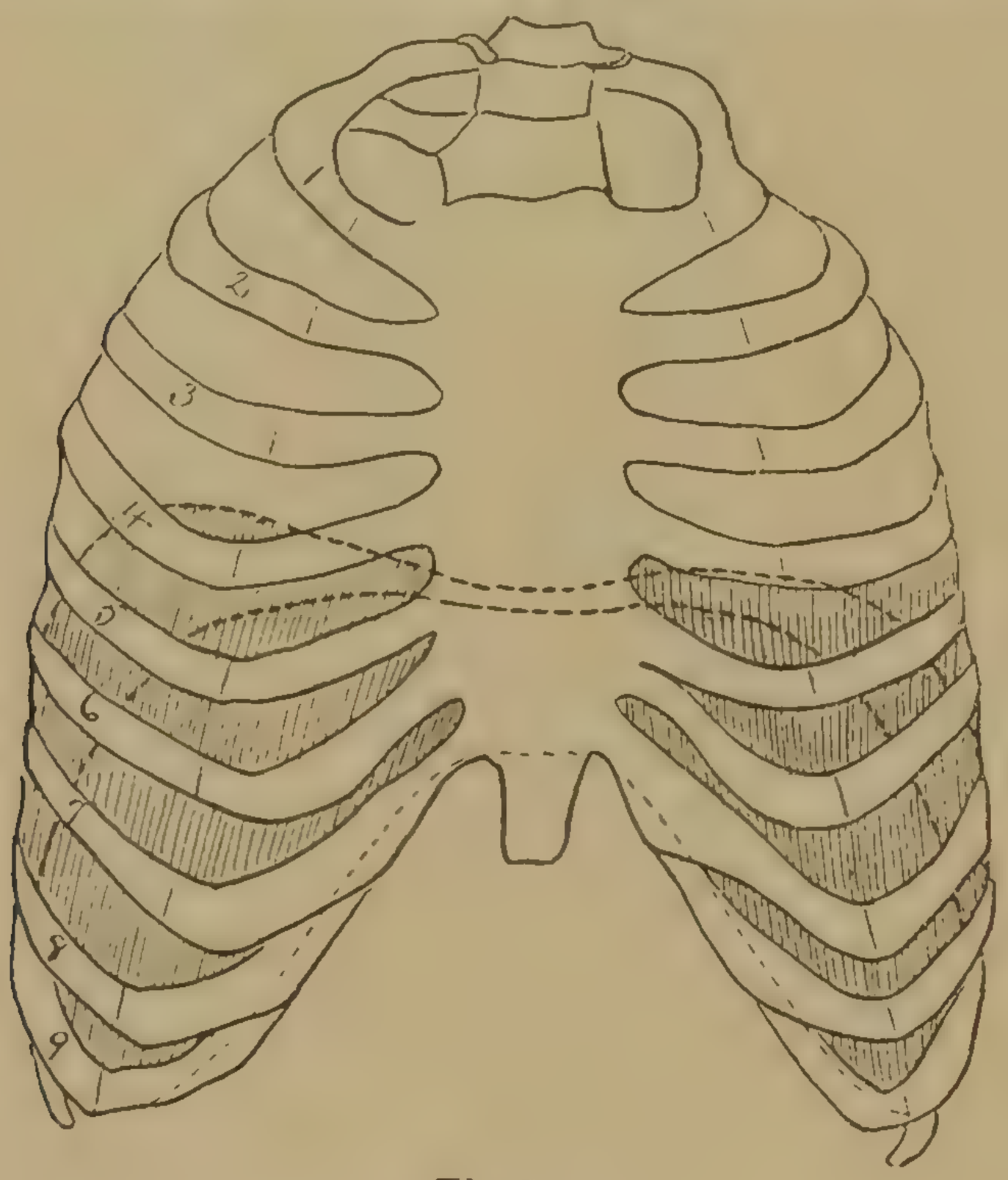


Fig. 7.

foramen. This opening is more common in the dog and is very detrimental to experiments. It is less frequently found in the guinea pig and rabbit. In monunguals (single hoofed animals) it is always present. When a foramen does not exist in the dog the mediastinum not infrequently ruptures at this point, when one side of the chest is opened, and allows both lungs to collapse. The septum is thinnest behind the second portion of the sternum, and the pleuræ diverge above and below from that point. (See fig. 9.) This space contains only a few glands and areolar tissue.

The middle mediastinum is the enlarged central portion which contains the pericardium and its contents, the phrenic nerves and accompanying vessels, the arch of the azygos veins and the roots of the lungs with their bronchial glands. The posterior mediastinum is situated between the pericardium, the diaphragm and roots of the lungs in front, and the spine behind. It contains between its pleural layers the descending thoracic aorta, the esophagus, the azygos

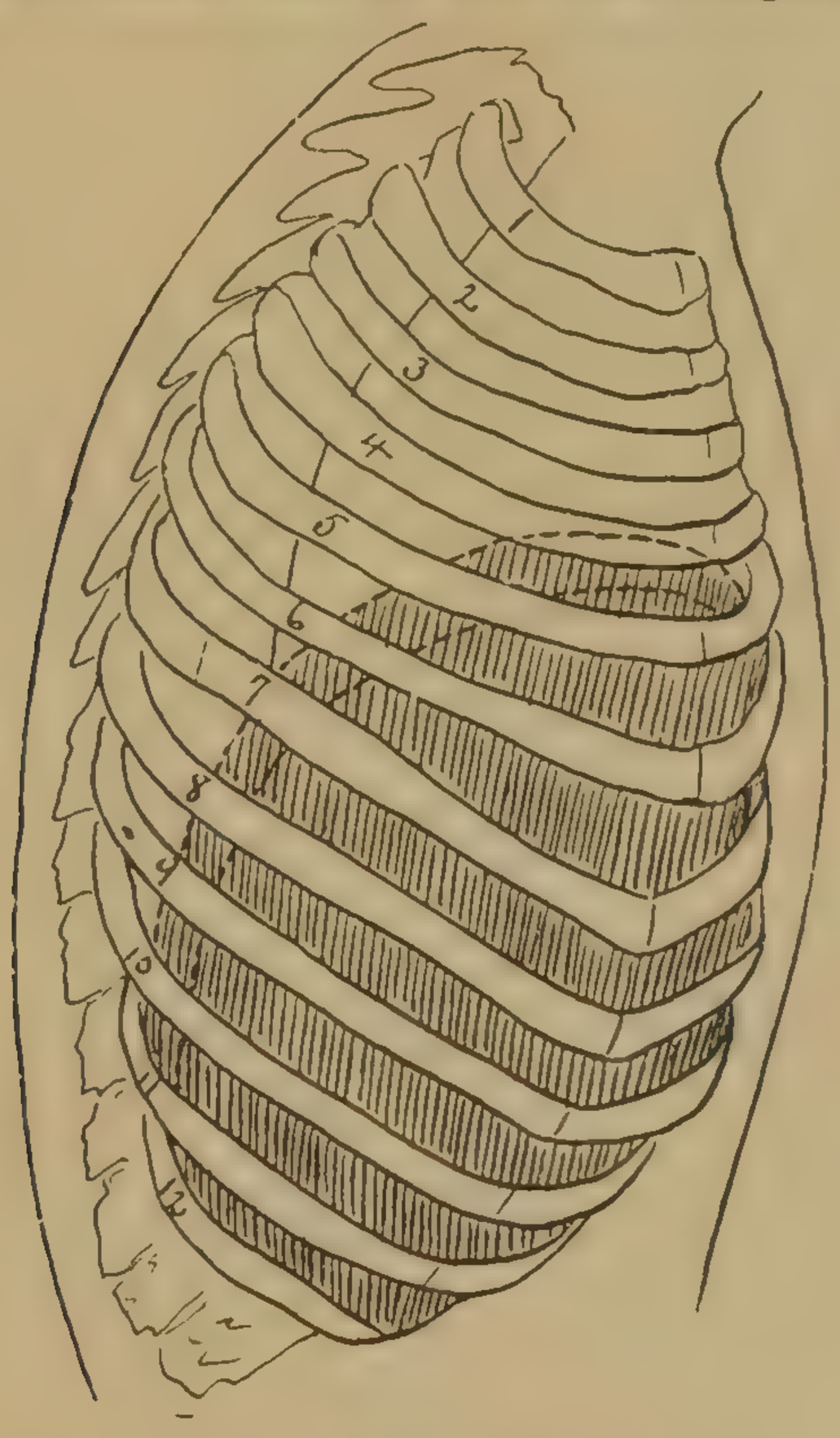


Fig. 8.

Figs. 7 and 8.—Highly arched diaphragm from front and side. The upper dotted line represents it when relaxed (expiration) and lower line when contracted (inspiration).

veins, the thoracic duct and the posterior mediastinal glands. We must be mindful that the lower half of the superior vena cava is in the middle mediastinal space close to the trunk of the pulmonary artery and vein on the right side and must not be included in the ligature nor torn in separating the adhesions at the hilum of the lung. The right auricle is also endangered in this position and has been injured in

experimental pneumectomy on animals. While separating an adherent diseased lung in a cadaver I tore directly into the auricle; after recognizing the condition it was difficult to separate the auricle from the pleura. Injury to the mediastinal contents is one of the greatest dangers in the operative technique of pneumectomy.

The pleura is a mesoblastic product like the peritoneum and meninges, or according to Waldeyer and His a hypoblastic product. It is composed of a thin fibrous layer covered with endothelia. It reacts rapidly to irritants, but is not so active in its reproduction as the peritoneum. It is a closed sac completely lining the chest wall and enveloping the lung except at its hilum and is divided into parietal and visceral laminæ. The pleura pulmonaris envelops and is firmly attached to the lung; it has depressions lining its fissures. The pleura costalis is attached to the ribs by a layer of connective tissue. In health it is practically impossible to separate the pleura from its attachment to the rib without opening its cavity. In disease it is often very much thickened and can be readily pulled off without the danger of pneumothorax. The pleura mediastinalis is attached to all of the important structures of the mediastinum, the esophagus, trachea, pericardium, vagus nerves, innominate artery, superior vena cava, phrenic, etc. These attachments are practically the same on both sides. The pleura is intimately attached to these structures and can not be removed without a careful dissection. In separating a lung adherent in the mediastinum great care must be taken to keep on the pulmonary side of the adherent pleura, as there is danger of rupturing important mediastinal structures; further, the two pleuræ may be adherent and in separating them the other pleural cavity might be opened. This would most likely occur between the esophagus and the aorta, in front of the seventh, eighth or ninth vertebral bodies, or on a level with the third interspace in front. (C. Jannesco.) (See Figs. 10 and 11, showing extent of pleura. See Fig. 9, showing approximation of the pleuræ at the seventh, eighth and ninth vertebræ.)

When the pleura is deflected from the mediastinum above, at the apex, it is attached to the innominate vein or the scalenus anticus muscle and further out to the subclavian artery and brachial plexus. The upper curve is flattened or concave in the center; it extends to a level with the neck of the first rib, but it is about three-fourths of an inch above the inner end of the clavicle. The attachment to the innominate vein and subclavian arteries are important factors in

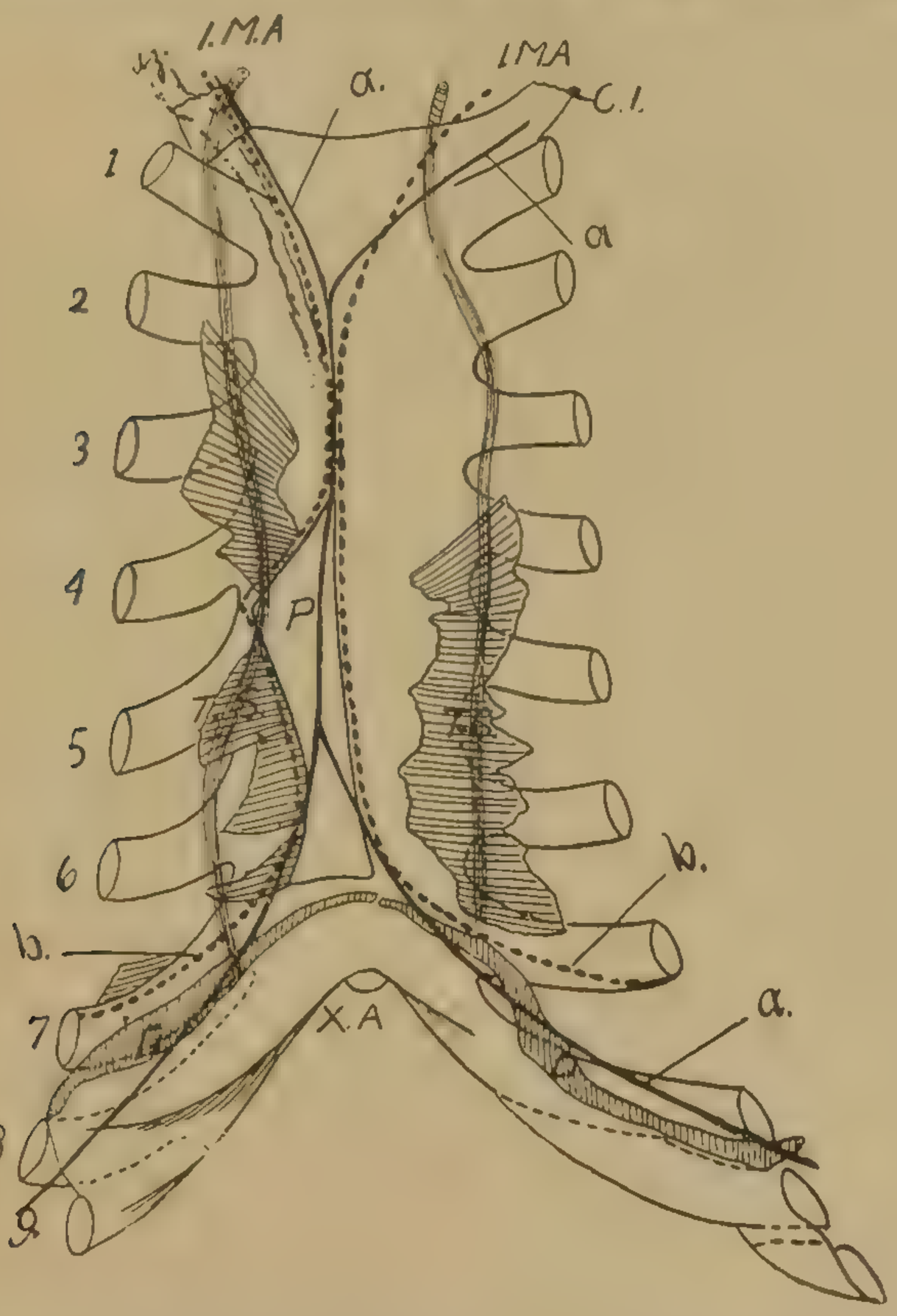


Fig. 9.—X. A., xiphoid appendix; Cl., clavicle; T. S., triangularis sterni; I.M.A., internal mammary artery; D., diaphragm; P., pericardium; a, line indicating usual position of pleura; b, dotted line indicating unusual position of pleura.

pneumectomy for apical disease, as adhesions are almost certain to exist. Visceral and parietal adhesions of the pleura at this point occasionally produce a paralysis of the abductor muscles of the vocal cord on that side and the symptoms of laryngeal paralysis.[10]

The lower limits of the pleura are somewhat variable; on the right side in front it is attached to the

[10] Fowler and Godlee.

sixth costal cartilage, the sixth space or the seventh rib and cartilage. From here it passes outward and downward to the eighth, ninth, tenth and eleventh ribs in an undulating and irregular manner and to the head of the twelfth rib and its vertebra. It often extends an inch to an inch and a half below the twelfth rib, and even below the costal arch along the margin. This occurs most frequently upon the left side, as on this side it is as a rule five-eighths of an inch lower all around than on the right. (See Figs. 10, 11.) The pleura diaphragmatis is deflected from these attachments and completely covers the diaphragm except at the mediastinum; it is thin and firmly attached. The sternal attachment of the pleura varies; it recedes gradually from the center at the lower margin of the fifth space on the right side; it recedes more abruptly from the fourth rib on the left side, exposing the pericardium in the fifth interspace immediately to the left of the sternum. The pericardium may be opened in this position without interfering with the pleura. The anterior attachment of the right pleura often extends to the left of the median line and even to the left margin of the sternum. In normal condition the visceral and parietal pleuræ are in close contact; effusion, hemorrhage and pneumothorax may change the positions.

The lungs.—The lung is an irregular, pyramidal semi-cone, concave in its center or hilum formed to the mediastinal contents; concave on its under surface for its adaptation to the diaphragm; it is convex and undulating in its entire outer surface. It does not extend to the limitations of the pleural cavity in many positions, particularly at its lower margin. The lower margin of the right lung starts at the cartilage of the sixth rib; it passes obliquely outward and downward to the seventh interspace in the mammary line and then almost vertically backward to the end of the eleventh rib. On the left side it is about three-eighths of an inch lower than on the right except in the incisura cardiaca, where the pericardium is exposed. It can be seen in comparing this margin with the lower boundaries of the pleura that the latter extends from one to one and one-half inches below

the border of the lung. Sappy claims that the lung extends as far as the border of the tenth rib behind and only to the fifth rib in front on the right and to the sixth on the left side. The general impression regarding the thickness and shape of the lower lobe is erroneous, as it is believed to extend almost inward from the margin described, while in reality the under

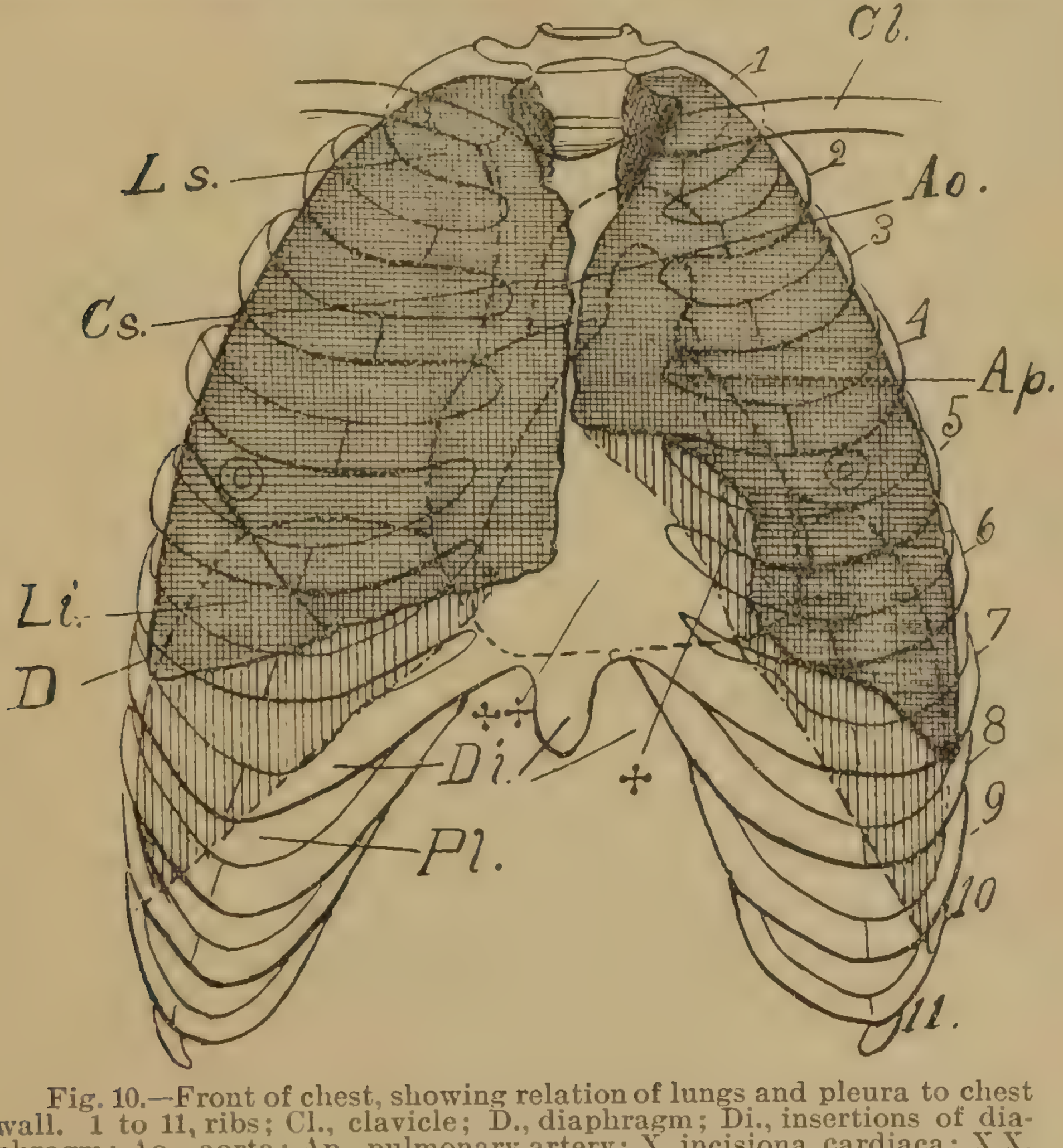


Fig. 10.—Front of chest, showing relation of lungs and pleura to chest wall. 1 to 11, ribs; Cl., clavicle; D., diaphragm; Di., insertions of diaphragm; Ao., aorta; Ap., pulmonary artery; X, incisiona cardiaca; X X, pericardium in contact with chest wall; Ls., upper lobe of lung; Lm., middle lobe of right lung; Li., lower lobe of lung.

surface is represented by an irregular conical excavation (formed by the diaphragm) extending from its base one inch to the inner side of the lower boundary of the lung all the way around up to a level with the fifth rib in the center near the hilum of the lung. (See Fig. 12.) The degree of elevation of this cone is changed in pathologic conditions. In intrapleural

effusions it may be depressed to a level with the eighth interspace. (See Figs. 10, 11.) With subphrenic pathologic products it may be elevated to the third interspace; in explorations with the needle the diaphragm may be punctured and the location of the exudate miscalculated, as the following case illustrates:

J. C., male, age 44, butcher; had suffered from dysentery

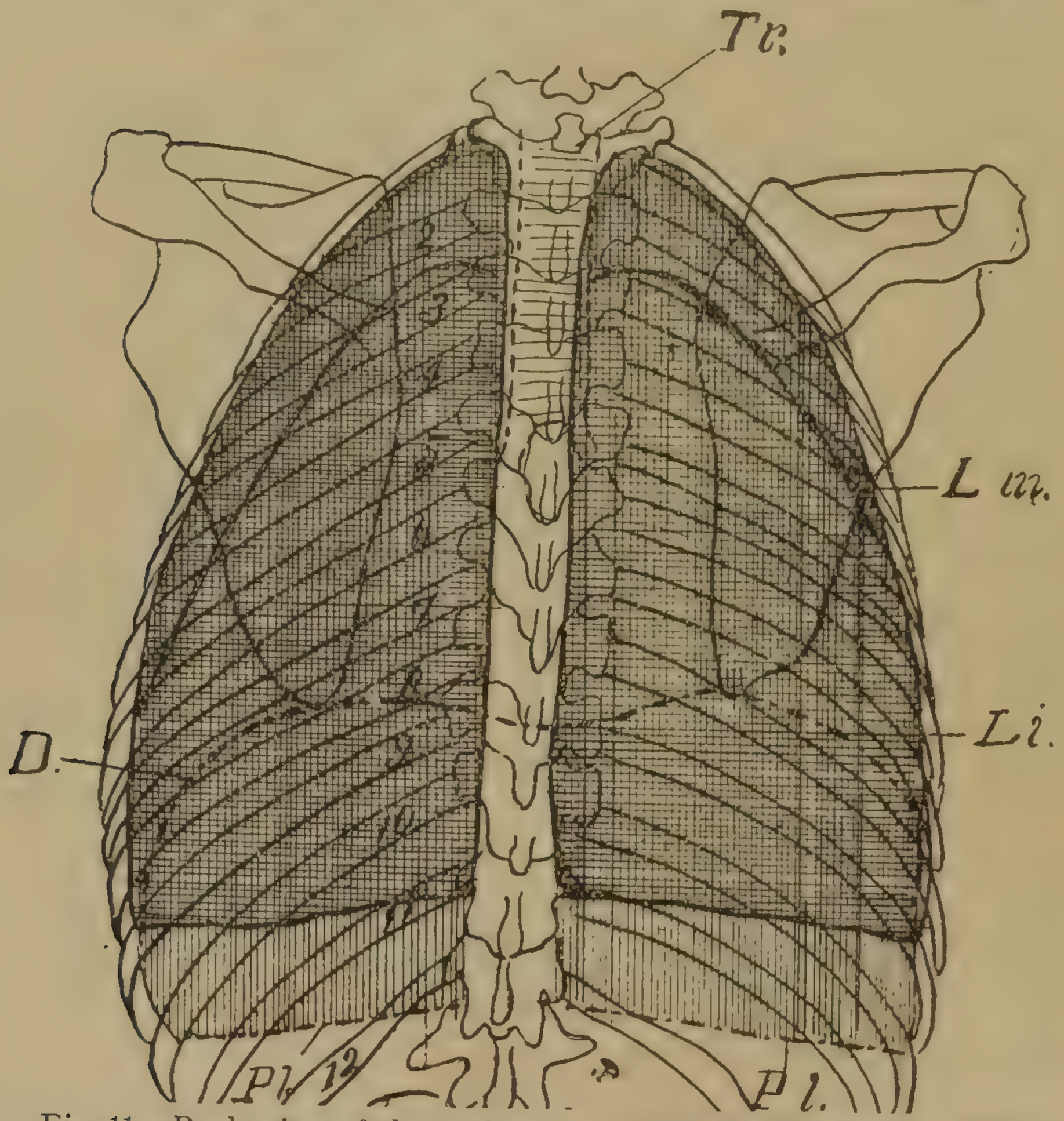


Fig. 11.—Back view of chest, showing relation of lungs and pleura. 1 to 11, ribs; Tr., trachea; D., diaphragm; Pl., Pleura; Lm., middle lobe of right lung; Li., lower lobe of lung.

for three weeks; was attacked with severe pain in the right side near the costal arch; this was rapidly followed by chills and fever, temperature reaching 105.3 degrees. Patient rapidly assumed a typhoid condition, low muttering delirium, dry tongue, tremor, etc. When the author saw him in consultation the dulness extended to the nipple in front and an inch above the angle of the scapula behind; there was a slight deviation with change of position, there was bulging of the intercostal spaces, and the line of dulness extended two inches below the costal arch. The diagnosis of hepatic abscess with

subphrenic and intrapleural rupture was made. An exploratory puncture in the seventh interspace, scapular line, first, on withdrawing the piston gave a clear fluid; the needle was introduced an inch further and the syringe filled with pus; diagnosis was changed to subphrenic, hepatic abscess. Operation proved the correctness of the latter diagnosis. The fluid first withdrawn was the secretion from the inflamed diaphragmatic pleura.

The apex of the lung is blunt and shows a depression where it is adapted to the subclavian artery, from which it is separated only by the pleura. The right lung is divided into three lobes by two fissures, the left into two lobes by one fissure. The great fissure in the right lobe separates the lower from the upper and middle lobes, and extends from beneath the second dorsal spine at first longitudinally outward and then obliquely downward to the lower border of the lung opposite the middle of the sixth costal cartilage, and usually passes below the nipple. (See Figs. 13, 14.) The middle fissure originates about the middle of the great fissure beneath the junction of the fourth interspace with the middle axillary line and passes almost horizontally forward following the line of the fourth rib to the fourth costal cartilage. It separates the upper from the middle lobe. These fissures extend almost to the hilum of the lung. (See Fig. 15.) In disease the pleura lining the fissure becomes adherent, obliterating the fissures; not infrequently these fissures are the seat of circumscribed serous and purulent pleuritic effusions and are mistaken for cysts and abscesses of the lung. The fissure in the left lung corresponds to the great fissure of the right except that it passes a little higher in front at the cardiac margin of the lung. (See Figs. 16, 17.) The pleura covering the lung is thin and firmly adherent. Anomalies as to the number of lobes and fissures are not uncommon, although the absence or non-development of a lobe is very rare; the most frequent anomaly is the absence of a fissure. Accessory lobes in the right lung have been recorded. In the dog as many as six have been found.

The right is the larger lung. An irregular notch in the left lung exposes the pericardium and gives the area of precordial dulness, which is irregularly

triangular in shape; its first point of the base is at the middle line of the sternum opposite the fourth costal cartilage; the apex of the triangle is at the point of the apex beat, and the second point of the base is at the junction of the ensiform cartilage and the body of the sternum. The hilum or root of the lung is situated in a depression at about the middle of the lung between its apex and its lower margin about equidistant from its anterior and posterior borders; it is

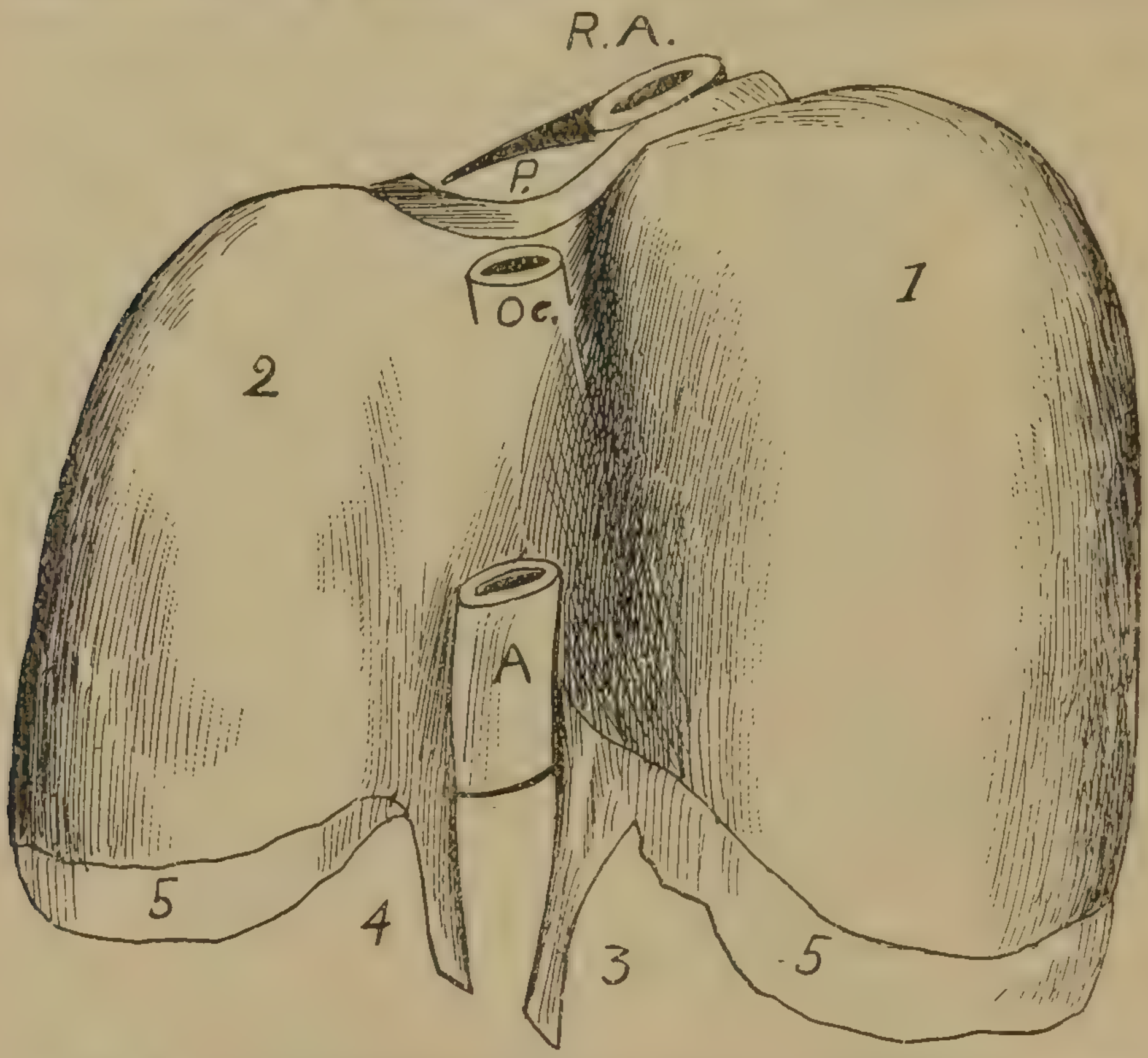


Fig. 12.—The diaphragm seen from behind. 1, right side of tendon; 2, left side of tendon; 3, right crus; 4, left crus; 5, origin from ribs; A, aorta; Œ, esophagus; P., pericardium; R.A., right auricle.

occasionally nearer the anterior. The root is composed of the bronchus and its subdivisions, the large blood vessels, nerves, lymphatics and glands, surrounded by areolar tissue and reflections of the pleura; the root is on a line with the fifth, sixth and seventh dorsal vertebræ and almost directly behind the fourth costal cartilage and third interspace, on a line with the longitudinal fissure. The order of arrangement in the root (see Fig. 18), on the right side from above

downward is, first, the pulmonary artery and its subdivisions; a little below that level and just behind is the eparterial bronchus; lower is the main bronchus behind and the pulmonary vein in front and a few smaller branches below; the left auricle presses in close to the bronchus behind and the right auricle

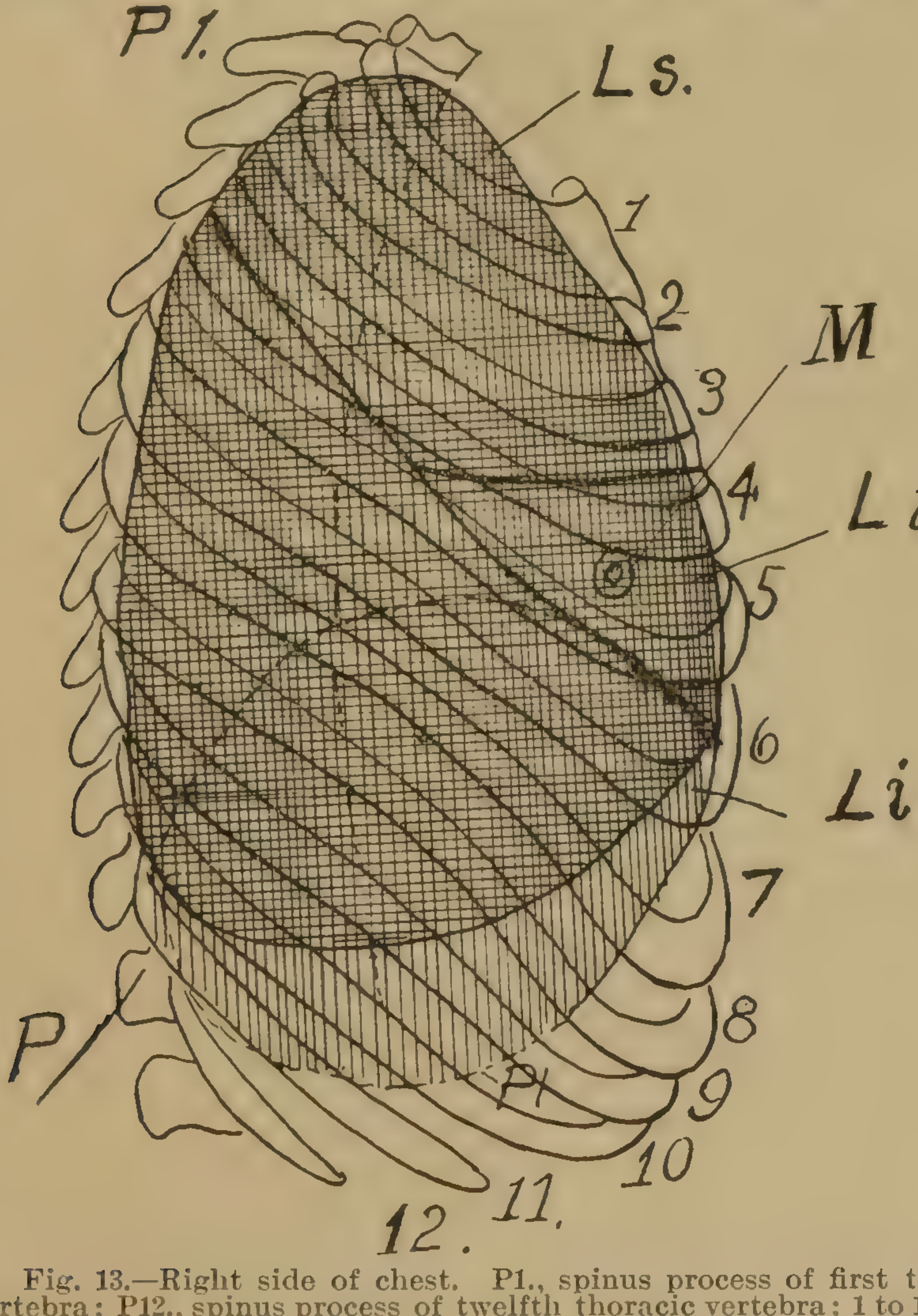


Fig. 13.—Right side of chest. P1., spinus process of first thoracic vertebra; P12., spinus process of twelfth thoracic vertebra; 1 to 12, ribs; M., nipple; Ls., upper lobe of lung; Lm., middle lobe of lung; Li., lower lobe of lung; Pl., pleura.

a little lower in front. The order of arrangement in the root on the left side from above is, pulmonary artery and subdivisions, the bronchus and subdivisions of pulmonary veins and the pulmonary artery. The root of the right lies behind the supe-

rior vena cava and part of the right auricle. The vena azygos arches over it to enter the superior vena cava. The root of the left lung passes below the arch of the aorta and in front of the descending aorta, appearing to come out of the hook formed by the aorta. It is situated a little nearer the anterior wall of the chest than the right. The phrenic nerves pass in front of the roots on both sides and the pneumogastric behind. The bronchi are in the same relative position, posterior to the large vessels; they can therefore be ligated in front separately from the bronchus in pneumectomy. The vena azygos must not be included in the ligature and must be carefully separated from the adhesions to the lung, so that the root of the lung can be brought well forward for ligation.

The trachea and bronchi.—The trachea which has from fifteen to twenty cartilaginous rings measures four to four and one-half inches in length and three-fourths to one inch in diameter; it is situated in the central portion of the mediastinum; the arch of the aorta passes across it in front just above its bifurcation. (See Fig. 19.) It divides into two bronchi, the right and left, on a line with the fifth dorsal vertebra, which lead to the corresponding lungs. The right bronchus is about one inch in length; it is shorter and wider than the left, and in direction is more continuous with the line of the trachea (Aeby); in size the transverse section of the tubes is in proportion of 100 to 78. The right is composed of six to eight cartilaginous rings, while the left, which is two inches in length, has nine to twelve cartilaginous rings. The rings are thin and cover about two-thirds of the circle of the bronchus, the remainder behind is membranous, resembling the trachea in this particular. The right bronchus gives off a branch to the upper lobe about an inch from the margin of the trachea. The external covering of the larger divisions of the bronchi is made up of connective tissue and a few muscle fibers. The connective tissue is greater behind, as it takes the place of the cartilage in that portion of the circle. This covering can not be peeled off the bronchus without laceration, rend-

ering it impossible to make a "cuff" when the bronchus is amputated, as we do in amputation of the appendix. The mucosa is a thin, delicate membrane made up of lymphoid cells and ciliated epithelia. The submucosa which secures the mucosa to the cartlage is thin and friable and easily destroyed with

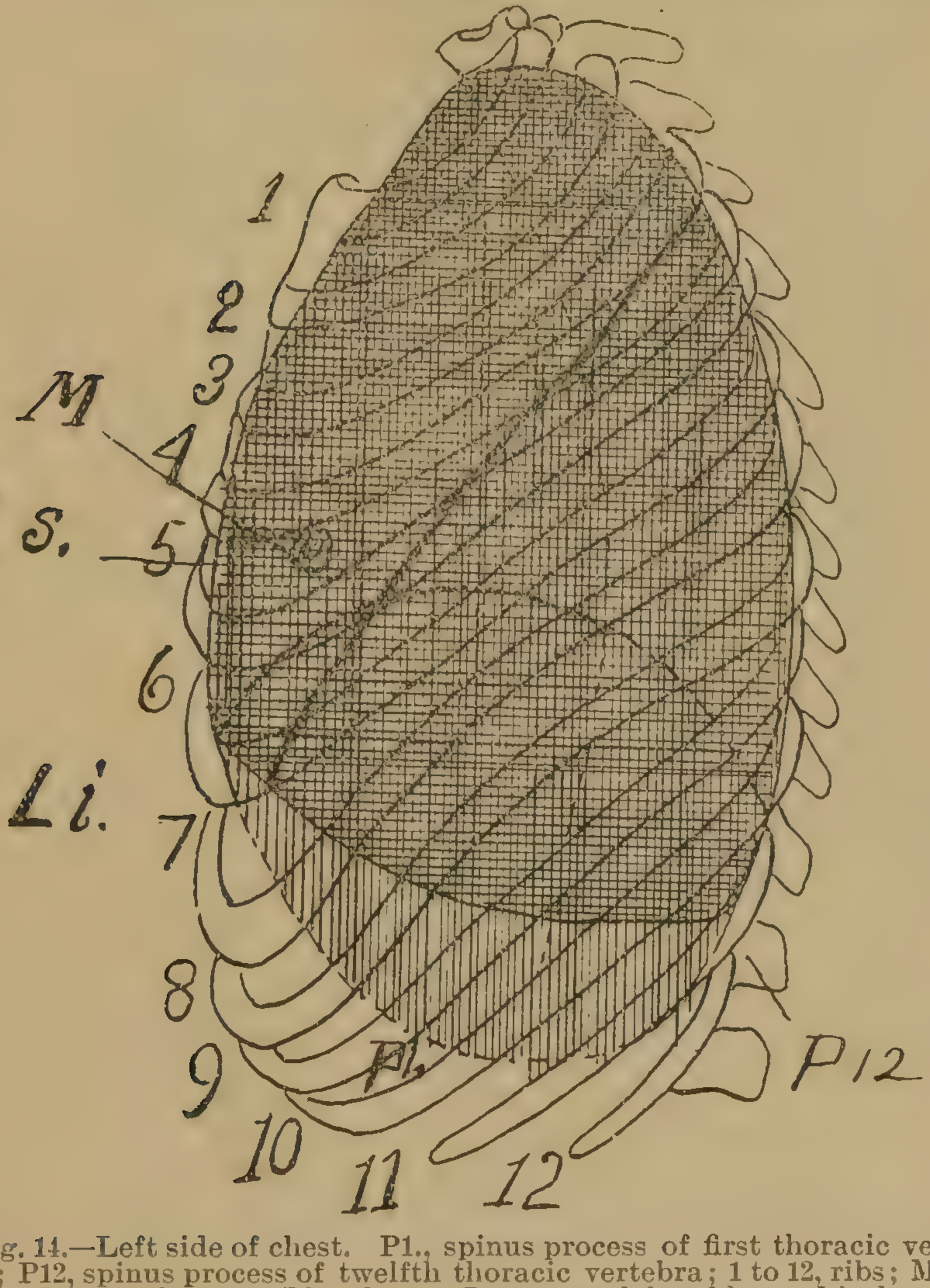


Fig. 14.—Left side of chest. P1., spinus process of first thoracic vertebra; P12, spinus process of twelfth thoracic vertebra; 1 to 12, ribs; M., nipple; D., diaphragm; Pl., pleura; Ls., upper lobe of lung; Li., lower lobe of lung.

pressure. It can not be peeled from the inner surface of the bronchus, nor can it be invaginated for the purpose of producing occlusion of the bronchus after pneumectomy. The histology of its method of closure will be described in the experiments.

PHYSIOLOGY OF RESPIRATION.

Respiration is essentially the intake of oxygen and the output of carbon dioxid by living cells. There are but two acts in the process, the external, the exchange of gases in and out of the blood; and the internal, the exchange from the blood to the cells. Mayow in 1668 discovered the real function of respiration, and declared that it was the absorption of nitro-aerial gases (oxygen)[11]. He also showed its similarity to combustion. Hale showed in 1726 that "noxious vapors were exhaled,"[12] and Black[13] showed these gases to consist of a "fixed air," carbon dioxid. Priestley, 1772, demonstrated that plants restored the property of supporting animal life to air which had been vitiated by animal respiration or by combustion. Lavoisier and LaPlace, 1777, taught that animal heat was the result of the oxidation of the tissues and was a process of combustion; they believed the action took place in the lungs, but admitted that it might be in other organs of the body. It was later shown that the quantity of oxygen consumed is generally much less in cold-blooded than in warm-blooded animals. Most insects are marked exceptions to this rule, as they have a metabolism equal to that of the larger mammals. The respiratory exchange in warm-blooded animals is influenced by age, size of body, external temperature, muscular activity, rest, digestion, hunger and hibernation. Cold increases and heat lessens the respiratory exchange. It is the reverse of what has been observed in cold-blooded animals. It was illustrated by Levoisier and Seguin, who showed that a man at rest at a temperature of 32.5 degrees absorbed in an hour 34.49 grams of oxygen, but at a temperature of 15, 38.31 grams of oxygen. Exercise increases the absorption of oxygen. (See Schaefer's Physiology, London, 1898). The hyperpnea following exercise is not due to excess of carbon dioxid in the blood as the result of increased metabolism, as the blood contains more oxygen and less carbon dioxid than during rest.[14] It is probably due to some product of muscular activ-

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11 Phil. Trans., London, 1666, p. 424: Ibid, 1670, pp. 2011-2035.
12 Statical Essays, 2d edition, 1731, Vol. 1, p. 236.
13 Lectures on Chemistry., Edinburgh, 1803.
14 Mathieu et Urbain: Arch. de Physiol.

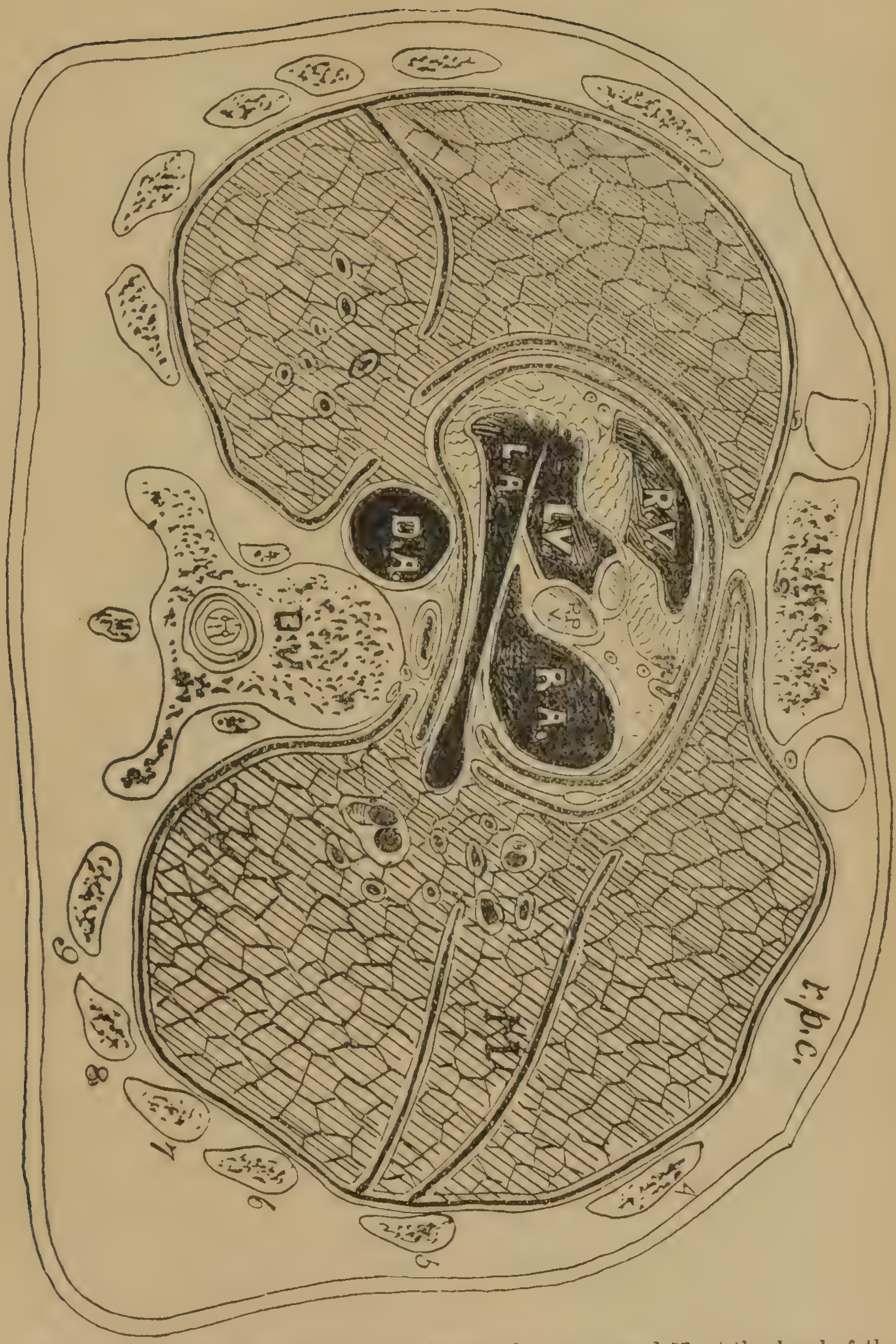


Fig. 15.—Horizontal section of the thorax of a man, aged 57, at the level of the nipple, as seen from above. N., nipple; M., middle lobe of right lung; R.A., right auricle; R.V., right ventricle; L.A., left auricle; L.V., left ventricle; R.P.V., right posterior valve of aortic orifice; r.p.c., right pleural cavity.

ity which is absorbed by the blood and carried to the medulla, there to stimulate the respiratory center. Tartaric acid injected into the blood increases respiration; sodium hydrate (n : 1 sol.) diminishes respiration.[15]

A man at work absorbs 91.2 grams of oxygen an hour, while at rest he absorbs 38.3 grams an hour at a temperature of 15 degrees C.[16] The carbon dioxid eliminated by a man at rest, asleep, is 161.6 c.c. per hour During a walk at three miles an hour, it is 851.2 c.c. an hour.[17] The percentage of carbon dioxid in the air exhaled is not changed, but the volume of air is increased.

Influence of food.—The ingestion of a meal upon respiratory exchange causes a marked intake of oxygen and output of carbon dioxid, due to the chemical changes which take place in food during digestion and absorption, and the increase of muscular and glandular activity of the alimentary tract. Smaller animals have a greater respiratory exchange than larger ones, other things being equal.

Influence of day and night.—There is a marked difference in the quantity of carbon dioxid produced between day and night. The increased exchange reaches its maximum from 11 A.M. to 1 P.M., and its minimum from 8 to 9 P.M.[18] The respiratory exchange is greater in the young than in the aged per kilogram under the same conditions.[19] Amphibia respire through the skin and mucosa of the alimentary tract, and in some this respiration is greater than that of the lungs. Cutaneous and alimentary respiration in mammals has been a field for considerable controversy, but it is the consensus of opinion that respiration takes place through the skin and alimentary canal. (See Cruikshank, Experiments on the insensible perspiration of the human body, showing its relation to respiration, 1871).[20]

The respiration of fetal life, or exchange of carbon

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15 Lehmann: Arch. f. d. ges. Phys., Bd. xlii, p. 284.
16 Levoisier: Loc. Cit.
17 Smith: Phil. Trans., Vol. cxlix, Pt. 2, p. 681.
18 Vierordt: Phys. Carlsruhe, 1845. Wagner's Handwörterbuch, Bd. ii u. iii, p. 883.
19 Ann. of Chem. and Pharm., 1843, Bd. xlv, p. 214.
20 Aubert and Lange: Arch. f. die ges. Phys., 1872, Bd. vi, p. 539.

dioxid and oxygen, is very much less than in adults, about the proportion of 1 to 100.[21] The respiration of the embryo in the egg of fowls and snakes takes place through the shell. If the egg is kept in a warm atmosphere of hydrogen for more than twenty-four hours the embryo ceases to live. The develop-

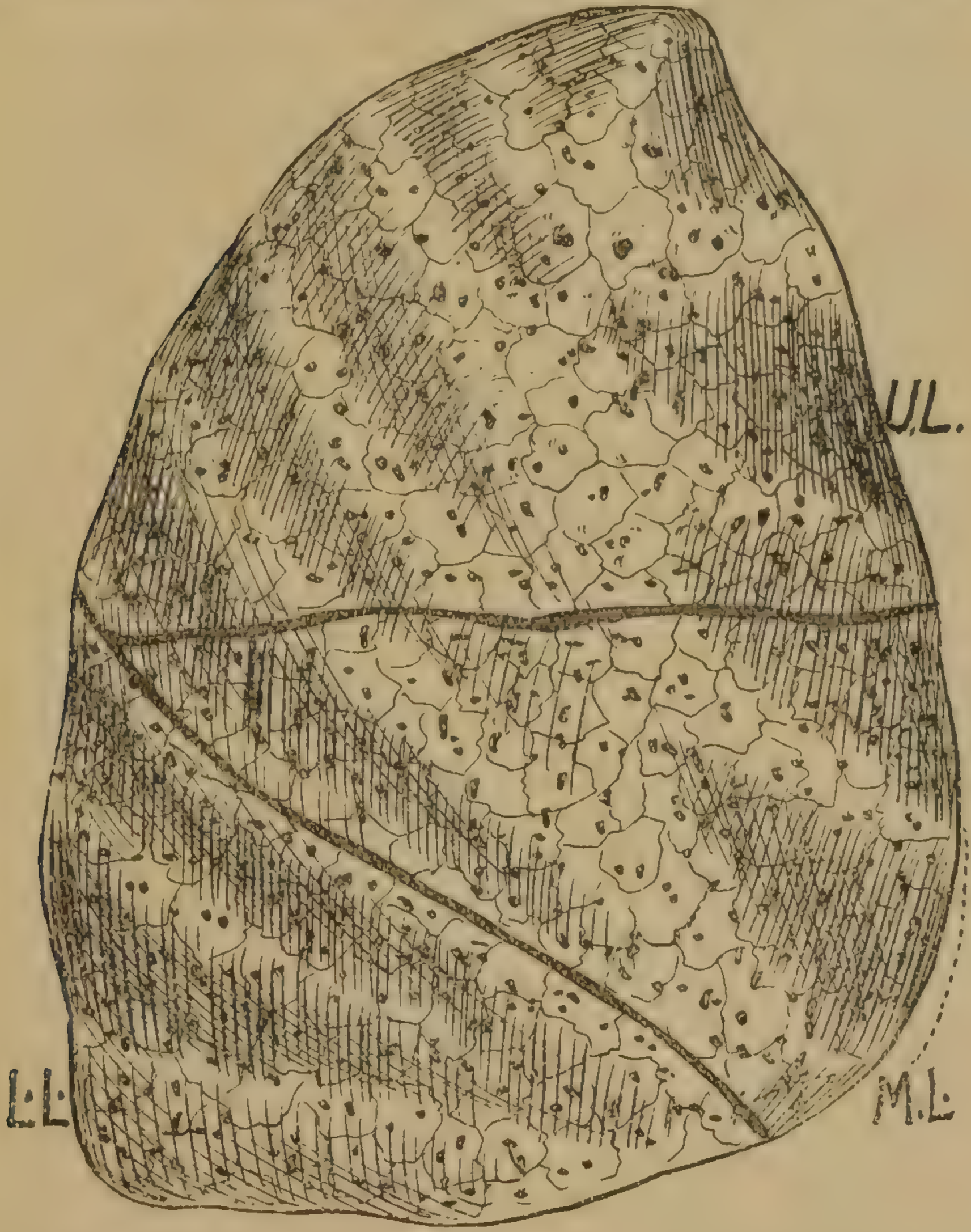


Fig. 16.—Outer aspect of right lung. U.L., upper lobe; M.L., middle lobe of lung; L.L., lower lobe of lung.

ment of the embryo is neither hastened nor delayed if the egg is kept in an atmosphere of oxygen.[22] This is in consonance with the exchange of oxygen in pulmonary respiration.

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21 Zuntz: Arch. f. ges. Phys., 1877, Bd. xiv, p. 605.
22 Pott: Arch. f. ges. Phys., 1883, Bd. xxxi, p. 268.

The amount of respiratory exchange in animals under normal conditions is not augmented by an increase of oxygen in the inspired air, but under pathologic conditions where the respiration is interfered with and where the blood is abnormally venous, an

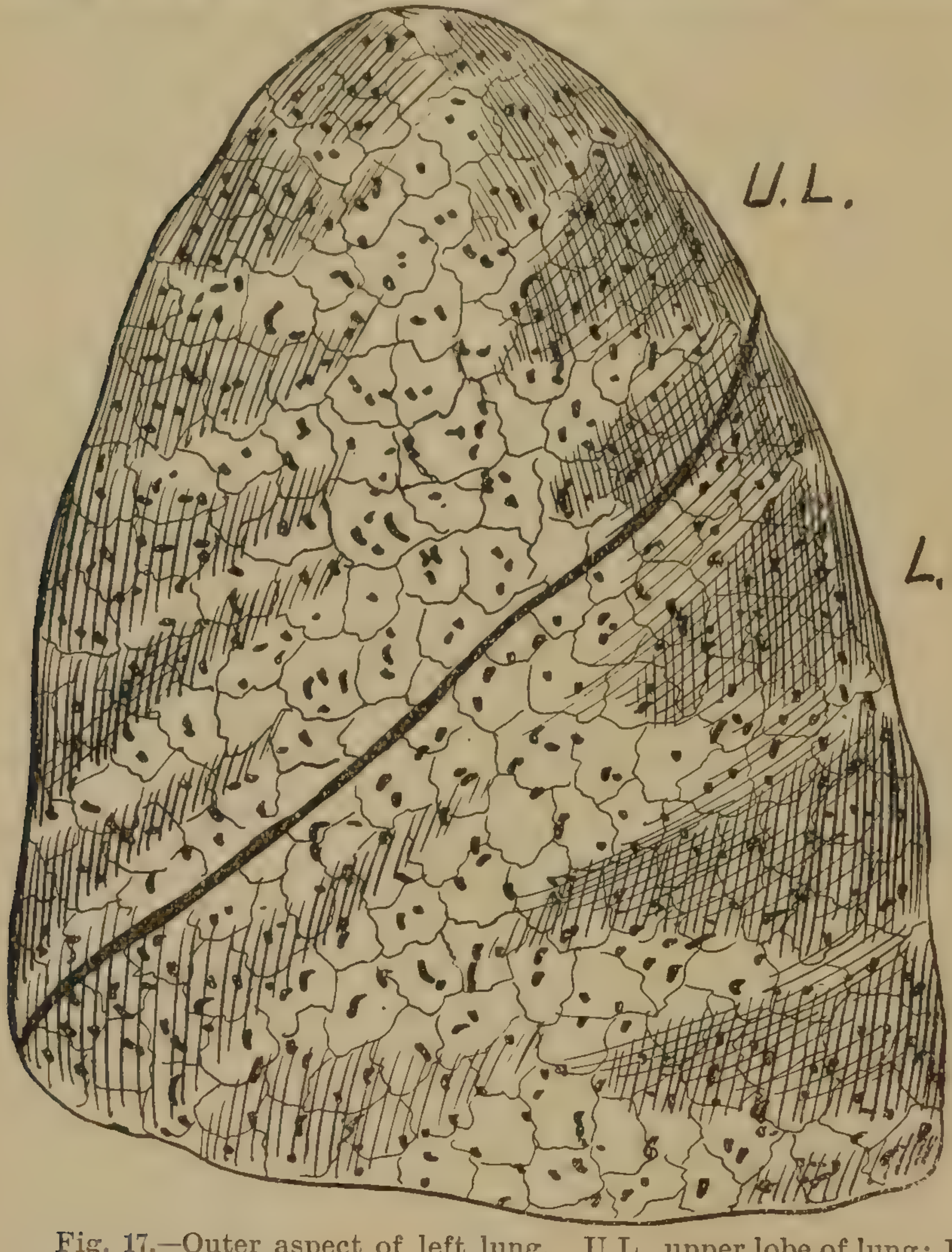


Fig. 17.—Outer aspect of left lung. U.L., upper lobe of lung; L.L., lower lobe of lung.

increase of oxygen in the air inspired produces an increased exchange of gases.[23] This is a physiologic indication for the clinical use of oxygen in certain pathologic conditions of the respiratory apparatus, as pneumonia, compression of the lung, etc., and is also a posi-

[23] Levoisier et Seguin: Hist. Acad. roy. d. Sc., Paris, 1789, p. 566.

tive indication for the administration of oxygen by inhalation after all operations which diminish the respiratory area of exchange.

The inhalation of air with a diminished quantity of oxygen produces marked symptoms, as observed in mountain climbing and balloon ascension. They are due to anoxemia, as was shown by Jourdanet.[24] The effect produced by air vitiated by repeated respiration is due to the deficiency of oxygen and the presence of carbon dioxid. The hyperpnea is due to the excess of carbon dioxid and not to the deficiency of oxygen. When the carbon dioxid exceeds 3 per cent. the hyperpnea is appreciable; at 10 per cent. it is marked; the frontal headache is due to the excess of carbon dioxid. When the oxygen is diminished to 12 per cent. the hyperpnea is appreciable and is excessive at 6 per cent.[25] Warm-blooded animals confined in a limited quantity of air die from want of oxygen and the blood is venous. The lack of oxygen produces its effect before the accumulation of carbon dioxid is sufficient to produce poisoning. Death takes place when the oxygen is reduced to 3 per cent. and the carbon dioxid increased to only 15 per cent. The fatal amount of carbon dioxid is 25 per cent.

The respiratory exchange in children and animals immediately after birth is very much less than later in life; this explains the fact that at this time they may be restored by artificial respiration a much longer time after respiration has ceased than could be accomplished later in life. The increase of respiration during exercise does not seem to be due to an increase of carbon dioxid or lack of oxygen in the blood, but to the accumulation in the blood of some product of muscular activity. If the exertion be continued its effect ceases, the pulse becomes slow, the respiration less frequent, and the man is said to have his second wind, after which the same degree of exertion may be continued with comparative comfort for a long time.

The quantity of air exchanged in each respiratory act is a matter of great importance from a medical as

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24 Jourdanet; Paul Bert's Work.
25 Haldane and Smith: Jour. of Path. and Bact., 1892, Vol. i, p. 875.



Fig. 18.—From Morris' Anatomy.

well as a surgical standpoint. What is the minimum tidal exchange which is consistent with life in man and what is the minimum of healthy lung tissue that will permit of that exchange? The tidal air in each respiratory act, in rest, is 114 to 196 c.cm., and 262 to 360 c.cm. during exercise.[26] The complemental air (the deepest inspiration) is 1722 to 1804 c.cm. (Hutchinson). The reserve air which can be expelled after an ordinary expiration is 1148 to 1804 c.cm. The residual air (mean) which remains in the lung after a forced expiration is 672 c.cm.[27] The vital capacity, quantity of air exchanged between the extremes of inhalation and exhalation, is 3558 c.cm. (mean for 1923 men).

A comparison of these figures shows what a great reserve respiratory power we have, and explains with what ease respiration may be carried on with a large proportion of the respiratory tract functionless. Our extreme capacity is 3558 c.cm.; in an ordinary exchange it is from 114 c.cm. at rest, to 360 c.cm. in exercise, therefore the extreme capacity is equal to at least ten times the quantity of ordinary exchange. Pathologically we recognize that with one lung entirely disabled by pleuritic effusion and the capacity of the other lung greatly diminished by displacement of the mediastinal septum, the respiratory exchange is still ample to sustain life. These physiologic and pathologic facts prove that with our surgical technic sufficiently advanced an entire lung may be removed, as the body can dispense with it.

The respiratory metabolism does not appear to be affected by the frequency of respiration except, as Pflüger has shown, to the extent of the increased demand made by the simple action of the respiratory muscles. The mean carbon dioxid elimination at seven respirations per minute in fifteen minutes is 7.836 grams, while in the same individual at sixty respirations per minute it is 7.868 grams. The conclusion therefore is, that the respiratory activity is determined by the *needs* of the tissues and not by the amount of oxygen carried to the blood. The temper-

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26 Hutchinson: Thorax, Todd's Cyc. of Anat. and Phys., Vol. iv, 1067.
27 H. Davy: Researches Concerning Nitrous Oxid, London, 1800, p. 399.

Fig. 19.—From Morris' Anatomy, showing relation of arch of aorta to trachea and bronchi.

ature of the inspired air in man is raised to that of the body before it reaches the smaller bronchi. The volume of expired air is 1/50 less than the inspired. The volume of oxygen in arterial blood in the dog was found to be 22 per cent. The volume of carbon dioxid in the blood varies greatly but is usually only about 1/5 or 30 volumes per cent. of what it is capable of holding when shaken in pure carbon dioxid, which is 150 volumes per cent. The proportion of oxygen in venous blood as compared with arterial blood is 5.43 per cent. in venous to 20.75 per cent. in arterial; carbon dioxid 61.8 per cent. in venous; 47.33 per cent. in arterial. The blood will not absorb an excess quantity of oxygen, no matter how great its excess in the air inhaled. The union is a loose chemic combination between the oxygen and certain constituents of the blood, principally the erythrocytes.[28] The hemoglobin in these erythrocytes is the absorbing element.[29] Nitrogen is merely held in solution. Carbon dioxid is held in chemic combination with the pigment of the red cells and the alkalies of the serum; and is also loosely dissolved in the blood. The proportion of loose to firm is as 2 to 3.5 (Prior). The alkalies of the blood are the most important constituents for holding in solution the carbon dioxid. The blood corpuscles contain about one-third of the total carbon dioxid held in the blood. The red cells contain 10 volumes and the white 2.5 volumes in 100 volumes of blood.[30]

Causes of exchange of gases.—At a temperature of 0 and a pressure of 760 mm.: The air inspired contains 20.96 volumes per cent. oxygen; the air expired contains 16.00 volumes per cent. oxygen; the air inspired contains 0.03 volumes per cent. carbon dioxid; the air expired contains 4.00 volumes per cent. carbon dioxid; the air inspired and expired contains about the same volume per cent. of nitrogen, 79.01.

Experiments have not accurately demonstrated the cause of the exchange of gases in the lung. It is the accepted provisional theory that the exchange of gases between the blood and the air in the lungs is effected

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28 Liebig: Ann. d. Chem. u. Pharm., 1851, Bd. lxxix, s. 112.
29 Pflüger: Arch. f. d. ges. Phys., Bonn, 1868, Bd. i, s. 73.
30 Setchinow: Cent. f. med. Wissenschaft., Berlin, 1877.

by physical and chemic means, the most important of which is diffusion.[31] The surface through which this diffusion takes place is 90 square meters, and through this there are diffused 300 c.c. of carbon dioxid and about the same quantity of oxygen per minute in ordinary respiration. The velocity of diffusion is proportionate to the density of the gas; therefore the velocity of carbon dioxid is about twenty times greater than that of oxygen (Zuntz). The question which concerns the surgeon in this relation is how much of the 90 square meters of this surface can be dispensed with suddenly and how much can be dispensed with slowly, the former by amputation or compression of the lung and the latter by disease processes? Clinical experience shows that one lung may be suddenly rendered entirely functionless without materially embarrassing respiration, as in pneumothorax and in hemathorax, and as I have demonstrated experimentally and therapeutically by nitrogen gas injections into the pleura. We find pathologically that one entire lung and a considerable part of the other may be rendered functionless by diseased conditions before the apnea becomes marked and distressing. The difficulty in respiration in the latter stages of tuberculosis is due to two causes: 1, to the diminution of the pulmonary tissue capable of performing its function; and 2, the principal one, to the restriction of the respiratory motions of the chest produced by the adhesions and the consolidation and cicatrization of the diseased portion of the lung. This defective motion does not produce the free ingress and egress of air to the functionating portion and thus does not cause sufficient respiratory exchange.

The internal respiratory exchange, the exchange of gases from blood to tissue, is due to the action of the cells themselves, the tissues having great affinity for oxygen, which they even store up for future oxidation. They are constantly producing carbon dioxid, this can only continue for a limited period of time in the absence of oxygen. The various tensions of gases in the different fluids of the body bear an important relation to their exchange.

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[31] Text-book of Physiol., E. A. Schaefer, London, 1898.

SURGERY.

We will first consider accidents to and operations on the lungs. Then we will consider the diseases of the lungs and the applications of surgical procedures to them. We will also consider the general pathologic and surgical principles underlying operative procedures on the lung. I propose the following proposition without argument: The important diseases of the lungs are all due to foreign bodies, either mechanical or bacterial. Therefore viewing the question from this etiologic standpoint, in the present state of medical science operative procedures should be habitually performed. The general principles are: 1. To place the tissue in such condition as to increase resistance to infection. 2. To remove: *a*, foreign bodies; *b*, the products of infection, which in turn are foci for further infection; *c*, tissue injured beyond repair, which constitutes foyers of new infection.

Lung operations divide themselves into two classes: 1. Those that do not perforate the visceral pleura. That class of operations aims to convert the hard-walled cavity into a collapsible one. The necessity for these operations arises from the physics of the lung. The indication is collapse, and is met by: *a*, an opening in the soft parts, allowing air to enter; *b*, removal of bony parts, allowing air to enter and the wall to collapse; *c*, collapsing the lung by forcible injection of gas or liquid into the pleural cavity. 2. Those that perforate the visceral pleura. They are divided into: *a*, those that simply perforate the lung —pneumotomy; *b*, those that remove all or some portion of a lung—pneumectomy.

What are the pathologic conditions, on the one hand, requiring collapse, on the other limiting the advisability of operative procedure to collapse? *a*, empyema; *b*, tuberculosis that is moderately advanced—too far advanced for pneumectomy.

In considering these subjects several questions arise:

1. Is the lung, situated in its bone-bound cavity, accessible to surgical manipulation? *a*, What are the difficulties and dangers encountered in entering this cavity? *b*, To what extent may this wall be removed and replaced and what manipulation is permissible within the chest?

2. What is the effect of opening the pleura—of pneumo-

thorax? *a*, Immediate—1, with adhesions; 2, without adhesions. *b*, secondary. How can its dangers be avoided or lessened?

3. Can the lung be incised? In pneumotomy what are the dangers and limitations? They are: *a*, hemorrhage; *b*, pneumothorax- 1, from opening in chest; 2, from opening the bronchi; *c*, inflammation--1, pleuritis (of same and opposite side); 2, pneumonia (traumatic); *d*, sepsis.

4. What are the pathologic conditions of the lung requiring incision- pneumotomy? *a*, hernia; *b*, injuries (infected); *c*, abscesses; *d*, bronchiectasis; *e*, gangrene; *f*, foreign bodies; *g*, tubercular cavities; *h*, hydatids; *i*, actinomycosis.

5. Can the lung be excised? In pneumectomy what are the dangers and limitations? They are: Immediate- *a*, hemorrhage; *b*, pneumothorax; *c*, dyspnea (causes and relief). Secondary -*a*, shock; *b*, dyspnea; *c*, hemorrhage; *d*, sepsis; *e*, pleuritis and pneumonia on opposite side. Best method of treating stump: Extra-thoracic, intra-thoracic, drainage or closure. Pathologic histology of repair of stump: Artery, vein, bronchus.

6. How is the chest filled after excision? What are the pathologic conditions in which excision is desirable or required? 1, Neoplasms of chest wall involving lung; 2, circumscribed tuberculosis.

7. Can the lung be defunctionalized? How may this be accomplished artificially and quiescence maintained? 1, By injections into the pleural cavity; 2, by resection of the ribs, which allows the chest wall to collapse; 3, thoracotomy, with separation of pleural adhesions and compresion of lung. What are the technical difficulties of intra-pleural injections? *a*, Adhesions; *b*, consolidations. What are its technical dangers? *a*, Air embolism; *b*, sub-pleural emphysema; *c*, pulmonary emphysema; *d*, dyspnea; *e*, sepsis--1, from without; 2, from within (1, tubercular foci, 2, septic foci). How can we determine that the injected material is passing into the pleural cavity and not into the lung tissue or bronchus? What is the most desirable material to use for injection? What are the effects of this pulmonary quiescence on the healthy lung--on diseased lung --particularly in tuberculosis? How long must a lung remain functionless that the process of repair in tuberculosis may be complete? Are pleuritic effusions beneficial or prejudicial to the repair of tuberculosis of the lung?

From the dawn of the history of medicine we find recorded cases of accidental penetrations of the chest by sharp or pointed bodies, as stakes, lances, sabres, bullets, forks, etc. The results of these accidents were hemorrhage, pneumothorax and pulmonary hernia, etc. An analysis shows that many of the cases recovered without surgical interference and that a smaller number did not even present symptoms of a grave character. With these cases as guides and

inducements for surgical exploration the surgeon was slow to act on the evidence which they presented. Large portions of the chest wall have been torn away accidentally and removed for tumors of the breast without opening the pleural cavity, and no special danger was attributed to the procedures. Incisions were made between the ribs for the relief of pathologic conditions from the time of Hippocrates, still it remained for Estlander, Schede and Delagéniere to popularize the free opening and removal of a considerable portion of the bony parietes. They have shown that over one-half of the costal framework of one side of the chest may be removed without any great danger. But in their operations they had present a pathologic condition of the pleura, which formed practically a secondary inner chest wall for the respiratory apparatus. As a corollary to their procedure we find recorded a number of cases of removal of the chest wall for neoplasm when there was no such secondary thoracic wall to protect the lung; the latter collapsed and the cavity filled with air. The extent to which the chest wall has been removed in these procedures can be estimated from the operations of Kolaczek,[32] Liesrink,[33] Sedillot, in the pre-antiseptic period, resected the rib, pleura and part of an adherent lung successfully; since then Mass,[34] Kroenlein, Miller and many others have opened the pleura and removed lung tissue successfully in operations on the chest wall. Cairo[35] collected twenty-seven cases and found that five died immediately after the operation and three somewhat later. He included cases in the pre-antiseptic period. In the later cases not a patient succumbed as an immediate result of the operation, so that the removal of the chest wall with opening of the pleural cavity is today a recognized surgical procedure. Weinlechner's case is an exception to the above; he removed a large myxochondroma of the rib, resected three ribs and left an opening in the chest wall as large as the palm of the hand; he was unable to secure a flap sufficient to cover the opening;

32 Arch. für Klin. Chir., b. 24.
33 Ibid, b. 26.
34 Verhand. des Chir. Cong., 1885.
35 Deutsch. Med. Woch., 1893, Bd. iii.

tampon of gauze; the patient died of a septic pleuritis in twenty-four hours. Kroenlein[35*] in 1883 removed a large portion of the chest for sarcoma of the rib which involved the pleura; in 1887 he removed from the same patient a recurrent growth involving the chest wall, pleura and lung; the latter was separated and the cavity was drained. The patient lived for seven years after the primary operation.

What are the dangers of operation on the chest wall? They are: Shock, hemorrhage, pneumothorax and sepsis.

Shock.—The shock from injuries and operations on the chest wall, without involvement of the internal viscera or the opening of the pleural cavity, is usually very slight, as may be estimated from the extensive thoracoplastic operations which are now in vogue, and will therefore receive no special consideration.

Hemorrhage.—Injuries during operation to the internal mammary artery are not likely to occur, as operations on the lung and pleural cavity do not usually extend so close to the sternum. Accidents with fatal hemorrhage from this artery have not been frequent. Situated as it is on the inner side of the chest wall (see Fig. 9) hemorrhages from it, except when the opening is large, are mostly internal and not easy of recognition. However, the regularity of its course in the upper part of the chest close to the sternum enables the surgeon to estimate with considerable exactness the probability of its involvement in a particular injury. In eleven cases reported by Tourdes, six died; all five cases recorded in the history of the American war terminated fatally. (Paget.) The diagnosis should be based on the location and direction of the penetration, the general signs of hemorrhage, accumulating fluid in the pleural cavity with collapse of the lung and occasional external hemorrhage from the wound or hemoptysis. Where internal mammary hemorrhage is seriously suspected the surgeon should have the courage of his convictions, enlarge the wound to the pleura and if necessary resect the cartillage, then the bleeding points may be recognized and ligated. Another method

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35* Berl. Klin. Woch., 1884, b. xxi, site v.

suggested is the placing of a ligature upon the proximal side of the injury in the second intercostal space within a quarter of an inch of the sternum. Ligation in loco is preferable, as hemorrhage from the vein, as well as the artery, is grave. We should have no more hesitancy in opening the chest wall for hemorrhage from its arteries or from the lung than we should in opening the abdominal wall under the same conditions, as with a hemothorax already present the lung is collapsed and the effect of a pneumothorax is of little importance. The question of hemorrhage from the intercostal arteries is of great importance to the surgeon. Fatal hemorrhage from an intercostal artery has followed paracentesis and simple thoracotomy for the relief of a pleuritic effusion, and many fatalities are reported from injuries to these vessels. Paget reports twenty-three cases, eighteen of which terminated in death; fourteen of these were operated, with eleven deaths, showing what a great mortality occurs from an injury to such a small artery. It should be borne in mind that deaths did not follow extensive operations on the chest wall involving these arteries, as in the Estlander and Schede operation, as the hemorrhage in these was easily controlled, but that they followed small incised, punctured and penetrated wounds; the most dangerous condition is a splitting of an artery. The hemorrhage presents the same symptoms which guide us in the recognition of hemorrhage from the internal mammary. The indications for treatment are compression and ligation. I mention compression first in order to emphasize that it should never be relied on, either as compression from within by a plug attached to a strong silk ligature or as pressure from without. Ligature including the rib on either side of the wound is also to be depreated. The intercostal wound should be enlarged and the bleeding point detected by the hot, pulsating stream against the end of the finger; better still, a subperiosteal resection of the rib should be made, which insures an inspection of the field and accurate localization and ligature of the bleeding points. It should be a surgical law and applicable here that when a surgeon is called to a primary or secondary hemor-

rhage his operation should be as radical as is necessary for the absolute control of the hemorrhage; he must not temporize, as these patients give him only one opportunity; if this is not taken advantage of they are lost.

Pneumothorax may be classed as traumatic, idiopathic (internal pathologic) and therapeutic. The apprehension of this condition has been the greatest barrier to the surgery of the chest, and still it has been one of the most common sequences to traumatism of the chest wall, as pneumothorax with or without emphysema following fracture of the rib. We ask, what are its dangers? Is the admission of air into the pleural cavity in itself a dangerous occurrence? If so, why? Is the danger due, 1, to the shock to the pleura from the admission of the air or to its absorption; 2, to compression of the lung and impairment of the respiratory exchange of gases; 3, to effect upon the pneumogastric filaments by the sudden contraction of the lung tissue; 4, to displacement of the mediastinal organs, constricting and affecting the cardiac outlets; 5, to displacement of the mediastinum, lessening the power of expansion of the other lung; 6, to increase of tension in the circulation by collapse and emptying of such a large quantity of blood from the lung into the general circulation. Different observers attribute the unpleasant effects produced by pneumothorax to the above-mentioned causes. That there is little shock or discomfort produced by the admission of air into the pleural cavity has been shown by numerous accidents to the chest, experiments and operations extending from the time of Hippocrates to the present day. The infrequency of unpleasant symptoms from traumatic pneumothorax may be estimated from the reports in the surgical history of the American Civil War; in 11,540 chest wounds, unpleasant complications from this cause were recorded in less than half a dozen (Paget). In twenty years' experience in emergency surgery of the large hospitals I have observed traumatic pneumothorax as a cause of unpleasant symptoms in but two cases; in both of these the wounds were small and situated in large bronchi near the

hilum of the lung. In my recent compressions of the lung by injections with nitrogen gas, in my first case 120 cubic inches having been used, there was only a temporary dyspnea produced. The patient was up from the table within five minutes and refused to go to bed. In my second case I injected 200 cubic inches; it produced quickened respiration, a feeling of constriction in the chest, slight dyspnea and tickling in the throat. In the normal conditions of the pulmonary organs with a perfectly developed mediastinal septum the opening of the chest for the admission of air is not a grave occurrence, although pneumothorax is a more serious condition than emphysema. There are circumstances which make pneumothorax dangerous to life, as when the air is admitted into the pleural cavity through a valvular opening either from within or without; in which condition it may attain a considerable degree of pressure. In perforating wounds of the chest, even when the external wall and a bronchus are opened, pneumothorax is not a necessary sequence, as the cohesion of the pleuræ (West, Brousse) as well as pathologic adhesions prevent its formation. This cohesion must be stronger than the contractile power of the lung, which is equivalent to about 7 mm. of mercury or $3\frac{1}{2}$ inches of water. In my experiments and in operations in which no pathologic adhesions have existed, I have not observed in a single instance that the lung remained in apposition with the chest wall when the upper air passages were free. I am convinced from a careful observation and demonstration of this point in experiments that the pleuræ do not remain in contact when air is admitted into the pleural cavity, even through pin-hole openings. With each inspiratory act the lung recedes from the chest in proportion to the freedom of the admission of air. In expiration, with the contraction of the chest, the lung appears to come closer to the opening in the chest wall, while it really contracts closer to the hilum. With large free openings sufficient to admit the hand, the lung in two or three expirations collapses to its hilum and remains there stationary without the slightest effort at expansion if the balance of pressure within the pleural

cavity and trachea is equal or when the greater resistance is offered in the upper air passages. An erroneous conclusion has been drawn by some experimenters, and the expression given in Paget's admirable work, "One may see the lung moving freely in respiration in an animal from which a great part of the wall of the chest has been removed. I have often made on dogs penetrating wounds on both sides of the chest larger than the opening of the glottis, and I know that an animal under these conditions lives a long time and dies only of a sort of gradual asphyxia." From this it would be inferred that the lung had an expansive power of itself, but this is not the case; the dog under such conditions lives for a time because in each rapid, jerky inspiration there is a vacuum or diminution of atmospheric pressure in the pleural cavity and to moderate filling of both lungs; but make these openings large and free and there will be an immediate collapse of the lungs in the respiratory act. With one pleural cavity open, divide the mediastinal septum so that the air passes freely into both cavities and there is an immediate and permanent collapse of both lungs without the slightest effort at re-expansion, either in inspiration or expiration. If one pleura remains intact and the other has free access of air the lung in the open pleura collapses on inspiration but expands on expiration, particularly when resistance is offered to egress of air in the upper air passages; by this method the air in the lung on the uninjured side in expiration is forced into the collapsed lung in the open side. I have shown by complete occlusion of the trachea with one pleura open and the other closed that an alternate expansion and contraction could be produced by the exchange of air from one lung to the other, the collapsed lung expanding in expiration and contracting in inspiration, the other lung performing the reverse of this action.

The first opportunity to observe this action of the lung in the human subject was afforded me in the case of a policeman injured by the explosion of a bomb in the Haymarket riot May 4, 1886. A considerable portion of the lower part of the right chest was carried away; the opening was so large that the

hand could be inserted into the pleural cavity. The lung could be observed contracting slightly in every inspiration; with the mouth open and the upper air passages free it expanded but very little in expiration; if, however, the upper air passages were closed when the patient expired the lung filled the entire chest cavity, and when an effort at coughing was made a hernia of the lung resulted. The patient succumbed in thirty-eight hours from the effect of continued hemorrhage from extensive laceration of the liver.

A second case, a bullet wound in the seventh intercostal space on the left side in the post-axillary line. The man stated that his antagonist shot from the left and behind. The question arose, was the diaphragm penetrated, and if so, was the stomach injured? The house surgeon, under my direction, enlarged the opening, resected the ribs to examine the diaphragm and stomach through the chest, which was the easiest route. It was found when the chest was opened that the bullet had penetrated the diaphragm about two inches from the chest wall; this opening in the diaphragm was enlarged and the finger inserted into the peritoneal cavity; the stomach was found uninjured and the opening in the diaphragm was closed. The wound in the lung could be readily examined; when coughing was produced the lung protruded from the chest wall, when he inspired it again contracted, it could be easily retained in the wound. The admission of air to the pleura produced no unpleasant symptoms, it only increased the frequency of respiration.

A third case, Miss M., admitted to Mercy Hospital June 11, 1896, for the drainage of a small cavity situated in the upper portion of the lower lobe of the right lung, under the fifth rib and between the scapula and spine. In resecting and elevating the rib the pleura was torn, the lung immediately collapsed and could be seen expanding on expiration and contracting on inspiration. The pleura in the neighborhood of the opening was irritated and the flap replaced; the intention was to perform a second operation after adhesion of the lung had taken place. The anesthetic was suspended when the chest was opened, there was no marked dyspnea and the respiration was only

slightly increased after the patient was returned to bed. She felt no inconvenience nor discomfort from the resulting pneumothorax. The quantity of expectoration rapidly diminished and when she left the hospital it was only about one third of what it had been previously. Two months later it was still more reduced and she refused to return to the hospital for the completion of the operation. May 20, 1898, I succeeded in locating this patient and made an examination. I found the cavity had increased in size and the quantity of expectoration was about double what it had been when she was first admitted to the hospital. She still refused operation.

It is not believed that the absorption of the air by the pleura produces any deleterious effects; as a rule it takes place slowly; cases have been reported in which the air disappeared from the chest very rapidly. Fowler and Godlee state that a quantity of air sufficient to give a tympanitic note all over one-half of the chest completely disappeared in three days. If the air remains long in the chest the oxygen is absorbed and the carbon dioxid and nitrogen remain. In my experiments, injecting the chest with nitrogen, it was found by means of the radiograph that at the end of five weeks there was scarcely an appreciable diminution of the quantity of gas in the pleural cavity. This demonstrates that pure nitrogen gas is very slowly absorbed. The length of time required for the absorption of a given quantity of sterilized air by the pleura can be easily determined by repeated X-ray exposures. The above mentioned experiments as well as the clinical effusions into the pleural cavity demonstrate that the dyspnea and other unpleasant symptoms of pneumothorax are not due to the diminished respiratory exchange from compression, nor due to the effect on the pneumogastric by the contraction of the lung.

There are no definite data to show that the sudden contraction of the lung upon the terminal filaments of the pneumogastric has any effect in producing the unpleasant symptoms that occasionally occur in pneumothorax. I do not see any good grounds for believing that the displacement of the mediastinal organs

produces a kinking of the large arterial or venous trunks at the diaphragm and in that way hampers the heart's action. We have the same degree of displacement of the mediastinum with effusion and hemorrhage without these unpleasant effects. We can allow, experimentally, the mediastinal contents in dogs to pass far to the left, and if they are immobilized there the dog's respirations are but little interfered with. This condition would apparently place the vessels at their greatest disadvantage as far as the outlets in the diaphragm are concerned, still produce no marked effect. It has been suggested that the increased blood pressure by the large quantity of blood forced into the general circulation by the contraction of the lung produces the unpleasant symptoms of pneumothorax. This theory is very far-fetched and I recall no analogous train of symptoms produced from increase in blood pressure by its being forced into the general circulation from other parts of the body. The most pronounced and dangerous manifestation observed in my experiments was when a medium sized opening, two inches in length, was made in an intercostal space and the air allowed to pass in and out with *some* opposition. The lung on the open side gradually contracted to the hilum; the mediastinal septum and contents flapped to and fro in respiration like a sail during a lull; when the dog inhaled, the mediastinal septum concaved greatly to the uninjured side; when he exhaled, it convexed to the opposite side. The chest ceased to be a cylinder for the piston, the diaphragm, in the respiratory act. The mediastinal septum became a second diaphragm which contracted and destroyed the aspirating or piston power of the true diaphragm. With this motion of the septum there was comparatively no exchange of air in the lung, there was merely a variation in the shape of the lung; the septum soon became emphysematous and ruptured. The dogs in this experiment had rapid, panting respiration, which shortly ceased. The respiration could be easily restored by placing the hand over the opening in the chest wall with the diaphragm either concave or convex; by keeping the hand in position for a few minutes, the cyanosis would disappear and the animal reacted to

his normal condition, proving that it was not the displacement of the mediastinal organs to right or left, not the diminution in the respiratory area, but the absence of secure pressure which forced the air out of the lung on the healthy side in expiration and aspirated it in inspiration. The mechanism of this action can be readily demonstrated on a half-filled rubber bag. I am convinced that the dyspnea following opening of the pleural cavity is due to the vibration of the mediastinal septum and contents destroying the piston action of the diaphragm.

In support of this theory I wish to call attention to the methods of relief reported by different operators in cases of dyspnea following opening of the pleura in surgical operations on the lung or pleura. The operators closed the opening regardless of the condition of the lung, as far as contraction and expansion were concerned, still the patients were relieved. Delagéniere filled a pleural cavity with water to prevent dyspnea after he had resected the rib and removed a very large quantity of pus from the cavity. It can be seen from this case that the respiratory area was not increased, the quantity of blood in or out of the lung was not changed and the pneumogastric filaments were not interfered with, but the chest cylinder was rendered complete by the immobilization of the mediastinal septum. Covering the opening in the chest with gutta percha to prevent the intake and egress of air would have accomplished the same result. When a drainage tube has been inserted into the pleura and dyspnea occurs the occlusion of the tube relieves it.

I found that by placing a forceps on the collapsed lung and drawing it into the opening the dyspnea was immediately relieved and respiratory movements were at once resumed, a forceps placed on the hilum of the lung immobilizing the septum had the same effect. I also noted that if the lobe were secured in the aperature and only partially filled it, it did not take part in the respiration, but the dog was relieved, due I believe to the steadying of the mediastinal septum. The plugging of the trap door orifice with the lobe or suturing it to the margin was the best method for relief of the dyspnea. Carl Bayer (*Prag. Cent. für*

Chirur., Leipsig, 1897, s. 37), when operating in a case drew up the collapsed lung and sutured it to the margin of the wound. The symptoms of dyspnea and collapse disappeared and this portion of the lung filled and emptied in respiration.

Infection of pleura.—There is great danger of infection when the pleural cavity is opened; this is particularly true in experimental work. The greatest fatality in operations on the lung in dogs and monkeys has been from a suppurative pleuritis, not alone on the side which was operated but on the opposite side; this was emphasized in the detailed reports of the experimenters, Gluch, Bloch, Schmid and Biondi. Just why a pleurisy should so frequently occur on the opposite side is not known, unless that in the dog the infection is transmitted through the thin mediastinal septum. The same pathologic condition has been noted by surgeons in the removal of tumors of the chest wall in which the lung was involved. The pleura of the dog is much more susceptible to infection than the peritoneum, or better, it has less power to resist infection than the peritoneum. The pleuritis may be of the dry fibrinous variety, or it may be associated with a large serous effusion. (Note experiment on April 24, in which the effusion was so great as to fill the pleural cavity on the side operated and to compress the lung on the opposite side.)

Septic pleurisy of a virulent and fatal character takes place with pneumothorax when there is a rupture into the pleura of a septic accumulation which previously communicated with the external air, as a bronchiectatic cavity, gangrene, suppurating or tubercular foci, subphrenic abscess, etc. West, Walsh and Fraentzel claim that 90 per cent. of all cases of idiopathic pneumothorax are due to tubercular phthisis. Havershon, in 1357 postmortem examinations of phthisical subjects at the Brompton Hospital, from 1885 to 1896, found that septic pneumothorax had occurred in 87. Paget reports a case of septic embolus of the lung and pneumothorax occurring in typhoid fever. Rupture of the lung has taken place through the alveoli without any recognized pathologic condition. T. E. Adams[36] reports a case of pneumothorax

with rupture of lung from an occlusion of the glottis. The dyspnea was sudden in making its appearance; there were marked physical signs of pneumothorax; its disappearance was rapid; the air was entirely removed in three weeks; there were no symptoms of inflammatory trouble in the lung, the author attributes this fact to the arterial and venous ischemia induced by compression. J. Ashhurst, Jr., reports a similar case following contusion of the chest with glottis closed; no fracture of ribs; it was followed by emphysema and hydrothorax; patient recovered without operation. Pneumothorax has been present in numerous cases of subphrenic abscess rupturing into the pleural cavity.[37] Pneumothorax associated with these infective processes has a great mortality; few, however, of the cases die immediately; most of them succumb to the secondary effects of the pleuritic infection.

Diagnosis of pneumothorax.—The diagnosis of pneumothorax, either traumatic or idiopathic, is not difficult. The latter (idiopathic pneumothorax) is due principally to tuberculosis; 3 to 8 per cent. of tubercular cases have pneumothorax (Eichorst, Guttmann, His). The absence of respiratory sounds, the distant bronchial breathing, the tympanitic percussion note, the displacement of the mediastinal contents and diaphragm, the bulging of the intercostal spaces and, if needed, the more positive evidence of the radiograph, confirm the diagnosis.

Treatment.—The treatment of pneumothorax depends upon the indications in the individual case. The traumatic cases rarely require surgical interference. Where, however, the displacement of the mediastinal organs is great and the dyspnea is distressing, it is an indication that there is a valvular opening which, with the jerky inspirations and frequent coughing, has produced a plus pressure in the pleural cavity on the injured side. This is often associated with an accumulation of blood and serum and may readily be relieved by a paracentesis or by the introduction of a small trocar protected with cot-

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36 London Lancet, 1887, Vol. i, p. 799.
37 Inter. Clin., Philadelphia, 1894, Vol. iii, pp. 159–161.

ton after the manner of a culture tube protection. The question would naturally arise, should paracentesis be performed in every case? It should if the relief of the air and fluid in the cavity were the only considerations, but as there is a laceration of the lung which must be closed, that organ is held compressed and immobilized by the air while repair of the lesion takes place. If the lung were allowed free expansion it would require a much longer time to heal the laceration and if the air were aspirated from the chest it would refill through the original rupture. If the trocar is not convenient and the symptoms are alarming, the scalpel may be used to make an opening close to the upper margin of the ninth rib directly below the angle of the scapula; Fraentzel and Senator favor this incision. Netter has shown that tubercular bacilli are always present when the pneumothorax is due to the rupture of tubercular foci in the lung, and that pyogenic and saprogenic germs are frequently found. The majority of cases of penetrating wounds of the chest pass through an aseptic course to recovery. When, however, the symptoms of septic pneumothorax with effusion are present, there is positive indication for immediate and free incision. The scalpel of the surgeon is too often withheld in this class of cases until the patients have passed beyond the possibility of recovery with its aid. An incision here can do no harm, can be performed with a local anesthetic and will save many lives if resorted to early. This rule with additional emphasis should govern the treatment of idiopathic pneumothorax, as it is practically always associated with septic pleuritis of a virulent type; if curable at all it is by early drainage, in occasional cases, in the early stage, irrigation with physiologic salt solution; later, possibly with a slight stimulating antiseptic. I believe irrigation of pleural cavities greatly overdone; the same may be said of irrigation of wounds in general. Free drainage is all that is necessary after the surface is once granulating, which practically protects it from infection and absorption by the exosmosis of the fluids. Perforations of the lung close rapidly, therefore the drain should be removed as early as possible. The treat-

ment of pneumothorax resulting from operations on the chest wall will be considered under pneumotomy and pneumectomy.

Hernia of the lung is a very rare occurrence; there are occasional cases mentioned through the literature, the histories of which are very interesting. Herniæ may be divided into two classes, simple and compound. The former, simple, includes those with internal laceration of the chest wall without an opening through the skin, and are produced by blunt objects which fracture the ribs or perforate the internal thoracic wall in the intercostal spaces. The compound are those associated with penetrating wounds of the thorax; here the lung is exposed in the wound or protrudes through the chest wall. The mechanism which produces the protrusion may be readily understood. The contractions of the chest wall on the same and opposite sides compress the air in the lungs; the opposition afforded the egress of air in the upper air passages produces intra-pulmonary tension which is relieved by the escape of the lung through the fissure. It is surprising what little pressure placed on a rubber tube inserted in the trachea is necessary to cause the lung to protrude many inches through an opening in the chest wall. A pressure equal to four inches of water suffices. A hernia may or may not have a true hernial sac of pleura, depending upon its etiology and the rapidity of its formation. In hernia of the lung we do not include the protrusions of the lung above the first rib into the triangular spaces of the neck when they are not associated with injury, nor that produced at this point by artificial respiration, as the case of Chosu of Brussels. The symptoms and the physical signs with the location of the protrusion are so characteristic that they can scarcely admit of error in diagnosis. An exception to this is when a hernia is associated with emphysema.

Treatment.—The question of treatment of the first class of cases, simple hernia, can be disposed of by fulfilling the indications of reduction and retention. The latter may be accomplished by a compress, which should be inelastic and fit the opening snugly. If the case has become chronic, operative treatment for

closure of the opening in the chest wall may be instituted (Tuffier's and Reclus' cases). Compound hernia of the lung forms one of its most interesting though not practical pathologic conditions, as the accident is so extremely rare. I consider the cases reported of great value as an index of the extent to which the lung may be interfered with in a surgical way. I take the privilege of quoting verbatim from Paget the case of Rolandus, published in the year 1499: "Called to a citizen of Bologna on the sixth day after his wound, I found a portion of his lung issued between two ribs; the afflux of spirits and humors had determined such a swelling to the part that it was not possible to reduce it. The compression exercised by the ribs retained its nutriment from it, and it was so mortified that worms had been developed in it. They had brought together the most skilful chirurgeons of Bologna who, judging the death of the patient to be inevitable, had abandoned him. But I, yielding to his prayers and to those of his parents and friends, and having obtained the leave of the Bishop, the master and the man himself, I yielded to the solicitations of about thirty of my pupils, and made an incision through the skin, the breadth of my little finger-nail away from the wound, all round it. Then, with a cutting instrument, I removed all the portion of the lung level with my incision. The wound resulting from this resection was closed by the blood issuing from my incision, and was dressed frequently with the red powder and other adjuvants. By the grace of God it cicatrized and recovery took place. It is true that one had to wait long for it. The patient, with his master, Rolandini, has since then made the voyage to Jerusalem, and has returned in good health. If you ask me what I should have done in this case if I had been called to it at once, I answer that I should have dilated the wound with a small piece of wood, keeping the lung warm with a cock or a fowl split down the back, and should then have reduced it, and kept the wound open till the portion of the lung was wholly mortified. If you still question me, to know how this man can live without his lung, I answer that the part remaining

within the chest profits by the nutriment destined for the whole of the lung, and so is developed, and that nature has been able to create supplementary parts in it, which is an easy thing in an organ which is soft and near the warmth of the heart."

A similar case was reported by Tulpins in 1674, in which the protruding portion was ligated and cut off with the scissors. Couvey collected fourteen cases treated by removal of the protruding lung, with twelve recoveries. A. Demons reports a successful case. The method of treating the stump in these cases consisted of ligation, with retention of stump in the wound, amputation with the cautery, or dressing with antiseptics and allowing the lung to slough or dessicate, as the tendency might be in the individual case, depending upon the circulation.[38] The fact that this class of cases recovered, after pneumectomy with the retention of the stump in the wound, led me to the experiment of amputation of the lung with extrapleural treatment of the pedicle and the production of primary hernia of the lobe, to be removed with secondary amputation. In compound hernia it is not necessary that the protruded portion should be amputated; if seen early it is better to cleanse and return the lung and resort to drainage of the most dependent portion of the cavity, close the opening in the chest by suture of the separate layers, and if necessary by a catgut suture of the fractured ribs.[39]

Wounds of the lung.—This subject is so extensive, and the cases are so common, that a volume might be devoted to their enumeration and analysis; still, they may be so grouped into classes for their general consideration that it will only be necessary to cite cases typic of each class. We will include here the cases of secondary infections following fracture of the ribs stab, bullet and pointed object penetrations. Infections following simple fractures of the ribs are very rare, considering the frequency of this injury. They are readily diagnosed and the treatment should be the same as that for compound infected injuries, considered later. A case illustrating the secondary infection

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[38] Bull. et mém. Soc. de Chir. de Paris, 1886, N. S. 12, p. 450.
[39] H. Hayberter: 1890, Lancet, 1893.

following fracture of the ribs is reported by Maydl,[40] in which a large quantity of the purulent fluid was removed from the lung three weeks after the accident, the pleura having been drained of blood and serum immediately after the injury; case recovered.

Stab wounds of the chest are common, but are rarely associated with serious symptoms. I recall a case which occurred in the Cook County Hospital; a patient received fourteen stab wounds in the posterior wall of the chest with a knife-blade $2\frac{1}{2}$ inches in length; many of these perforated the chest wall, still the patient suffered no serious inconvenience; there was a slight pneumothorax and hemoptysis for the first two days; the temperature did not exceed 100 degrees at any time and he made an uneventful recovery. This is illustrative of the ordinary course of stab wounds of chest with pocket knives. The lung, like the intestine, is not injured by a stab wound unless it be adherent or the penetration takes place at its hilum or mesentery. Hemorrhage, pneumothorax and hemoptysis are not common after stab wounds. The indications in these cases are to clean and seal the external wounds; administer the necessary medicines to prevent coughing; never probe or explore; refrain from protracted examinations, and allow the patients to remain in the recumbent position. If infection follows they should be treated the same as infected bullet or other penetrating wounds.

Bullet wounds of the chest produce a great variety of pathologic conditions, and still a very large percentage of the cases pass through an uncomplicated course to recovery. This great difference in the course and results of cases is due to the portion of the lung penetrated, the size and character of the missile, the involvement of the large vessels and bronchi, the presence or absence of infective material and the sequence of infection. Penetrations of the periphery of the lung by bullets, as a rule, do not produce serious symptoms; there is but slight hemoptysis; this is estimated to be present in less than 20 per cent. of the cases of bullet perforations of the lung; its presence does not positively indicate perforation, though prac-

[40] Wien. Klin. Runds., June 23, 1895.

tically it has that significance; there is no appreciable hematothorax; shock, pallor, feeble pulse, apparent anemia in bullet wounds of the lung do not necessarily mean hemorrhage, as they are often pronounced when there is no appreciable quantity of blood in the pleural cavity. This fact must never be lost sight of when thoracotomy is contemplated for the relief of hemorrhage. There is usually diminution of the respiratory action on the injured side and occasionally a limited pneumothorax; on the third or fourth day after the injury there may be evidence of a circumscribed traumatic pneumonia which rapidly subsides and then the patient is convalescent. Contrast this with the course of a case in which the bullet penetrates the hilum and is associated with severe intra-thoracic hemorrhage. The patient, after the injury, is collapsed, becomes pulseless, his respirations are increased in frequency and are of a sighing character; the lung on the injured side has collapsed and within a short time the patient succumbs. This is the class of cases in which surgical interference can not be considered for the relief of hemorrhage, as they terminate fatally before surgical interference is possible. It is in cases of hematothorax where the escape of blood is slow or secondary that thoracotomy with ligation, compression or cauterization of the bleeding point comes into consideration. It has been suggested that allowing the lung to collapse would produce hemostasis. Clinical experience and experiments have demonstrated that it has no such effect, that induced pneumothorax does not act as a hemostatic and therefore should not be resorted to. In reviewing the cases of hematothorax that have been treated by open incision and ligation I have been impressed by the almost unanimous failure of mention of unpleasant symptoms from the pneumothorax produced by the operation. Whether the absence of symptoms was due to the fact that the lung was collapsed before the operation by the accumulated air or blood I do not know, but the practical fact is the same, and its clinical significance is that under these conditions the chest may be opened with little apprehension as to the pneumothorax producing unpleasant symptoms. This obser-

vation might indicate the filling of the chest with fluid or air before performing pneumotomy or pneumectomy. Of 98 cases of fatal gunshot wounds of the chest occurring at the siege of Strassburg 24 were due to hemorrhage into the pleural cavity alone. (Beck.) Of 65 penetrating wounds of the chest in military practice by Sir Wm. McCormack and Fisher 36 terminated fatally, which is a very much greater percentage than appears in civil practice. External hemorrhage is not common with gunshot wounds of the chest; occasionally there may be some bleeding from vessels situated in the outer portion of the thoracic wall. It must not be forgotten however, that in wounds of the intercostal and mammary arteries the hemorrhage is more likely to be internal than external and these small vessels should be examined first in all operative procedures. We have no means of determining without exploration whether the hemorrhage is from the chest wall or the lung itself. Quénu, Michaux, Berger, Delorme and Reclus warmly advocate surgical interference when the evidence of hemorrhage is unmistakable. Omboni[41] excised two different portions of the same lung for a bullet wound; the anterior margin of the upper lobe had a V-shaped piece removed, followed by accurate catgut suture; through the same opening of the chest a portion of the lower lobe was drawn forward, ligated *en masse* and excised; drain inserted. Patient died on sixth day. Postmortem: Fatal pyemia from sub-serratus magnus infection; stump in good condition and healing; cause of death, defective drainage of external portion of wound. V. Richards[42] successfully excised pneumocele following penetrating wound of the thorax. Delorme and Robert operated, but patients were in such bad condition that they died within fifteen minutes after operation.

From careful examination on the cadaver and from my experiments on the dog, I am convinced that many lives can be saved by early intervention in cases of intrathoracic hemorrhage either by ligature with or without amputation, suture with catgut or cauteri-

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41 Bull. de Comit. Med. Cremonese, Cremona, 1884, iv. p. 228.
42 Indian Med. Gaz., Calcutta, 1880, xv. p. 213.

zation with the Paquélin. I have little confidence in our ability to produce hemostasis by packing such an elastic and easily infiltrated tissue as the lung; the suture is preferable and should be performed with a round needle and absorbable material; the greatest antiseptic precaution should be exercised.

The secondary changes which occur after bullet wounds, as pneumonia, abscess, gangrene, pyo-hematothorax, empyema, septicemia (sapremia) and pyemia are of much greater importance and deserve more attention than is usually given them either in the text-books or in recent monographs on this subject. The pneumonia in many cases is limited, in others it may involve a lobe or an entire lung; it often has marked evidences of acute pyogenic infection extending even to gangrene of the infected portion. Pyo-hematothorax and empyema may occur shortly after a bullet wound of the chest. The patient shows, in addition to the symptoms of depression and shock from the hemorrhage, manifestations of infection, not necessarily a great elevation of temperature but other marked evidences of septic intoxication, as dry, coated tongue, delirium, thirst, rapid respiration, etc. These symptoms usually present themselves on the third or fourth day after the injury and rapidly increase in severity until the patient succumbs from the sapremia on the seventh or eighth day unless rescued by surgical interference. The dictum of non-interference in gunshot wounds of the chest has taken such root in the profession that even unquestionable evidence of putrefaction and suppuration within the chest does not call forth active response on the part of the surgeon to afford relief. A patient with the same evidence of sapremia or septicemia in other parts of the body is immediately assisted by the surgeon, while in bullet wounds of the chest procrastination is the practice. I wish to emphasize that whenever there is evidence of putrefaction or suppuration the chest should be immediately opened and drained the same as the peritoneum or cellular tissue would be under the same conditions. I cite here a case of this class:

J. C., male, aged 27, admitted to Alexian Brothers' Hospital June, 1895; three hours previously was shot from in front with

a 44-caliber bullet which passed into the chest and fractured the fifth rib; it lodged under the skin behind near the angle of the eighth rib, which was fractured. The first day he was suffering from slight dyspnea, some pain on the right side, had expectorated a small quantity of blood and had pneumothorax. The following day his temperature was 100 degrees, pulse 94, respiration 32, tongue slightly coated. At noon of the third day his temperature was 103 degrees, dulness extended up to the axillary line in the recumbent position, tongue slightly coated, and he was mildly delirious; bronchial breathing could be heard over the upper portion of the chest behind; this was probably transmitted. Fourth day—When I arrived at the hospital at 12 o'clock temperature was 105 degrees (rectal). pulse 160, respiration 42; he was cyanotic, unconscious and in a low, muttering delirium. He was placed on the table and without anesthetic a resection of the eighth rib was made at the line of fracture. The bullet and fragment of cloth were removed from the muscle wall, also a large quantity of offensive bloody debris and fluid from the pleural cavity. The opening at the point of entrance of the bullet was enlarged and an irrigation of the cavity with sterile water was made. The day following his pulse was 132, temperature 102 degrees, respiration 36; his delirium had almost subsided and his general appearance was improved. In another twenty-four hours his temperature had dropped to 100.2 degrees, his respiration 28 and pulse 124, and his general condition was still better. From this time on his improvement was rapid. The drainage tube was removed on the sixteenth day and in three weeks he left the hospital.

This case is typical of its class, and similar cases may be observed almost any time in the hospitals of large cities. The rule is, however, that they are allowed to go on to death without surgical interference, as the following case illustrates:

M. C., age 19, admitted to Alexian Brothers' Hospital May 16, 1893. A 44-caliber bullet penetrated the anterior wall of the right half of the chest fracturing the third rib. The patient was very much shocked from the injury; pulse was 130; skin cold and clammy and countenance blanched; anxious expression; there was a marked area of dulness over the lower half of the right chest; pneumothorax of the upper half; hemoptysis was continuous but not severe. The following day the patient's temperature was 101 degrees, pulse 118, respirations 54. He requested to be discharged from the hospital and under strong pressure was persuaded to remain another day. The third day his respirations were 40, pulse 150, temperature 103 degrees. He was delirious. Operation was advised but the parents would not consent. He was taken to his home, where after surgical consultation it was decided that he could live but a few hours and that interference would be futile. The death took place five days after removal from the hospital. The attending doctor told me that his condition remained about

the same until the end. The postmortem revealed a penetration of the middle lobe of the right lung and the upper portion of the lower lobe. There was a fracture of the seventh rib at its angle, the bullet had dropped back into the pleural cavity. The chest was full of an offensive sanguino-purulent fluid; there was a cloudy swelling of all the tissues, no metastatic abscesses. The cause of death was acute septicemia.

This case shows how long a patient, with this variety of infection, may live after his condition seems hopeless. I might cite many similar cases from the emergency wards of the county hospital. We hope the surgery of the future will lend a helping hand to stay the mortality from secondary infection in gunshot wounds of the chest. Simple incision and drainage may be all that will be necessary, but there should not be the slightest hesitancy in resecting one or more ribs and making a free incision in the pleural cavity in its most dependent portion regardless of the point of entrance or exit of the bullet. The clinical course and treatment of penetrations with other sharp-pointed instruments is based on the same pathologic and therapeutic principles as stab and bullet wounds; the lung is rarely injured with these instruments and primary drainage is more frequently indicated.

INFECTIVE LESIONS OF THE LUNG WHICH CONCERN THE SURGEON.

The surgical infective lesions of the lung are abscess, bronchiectasis, gangrene, foreign bodies, cysts (echinococcus and dermoids), tuberculosis and actinomycosis. Abscess of the lung is not as common a pulmonary affection as might be inferred from the number of cases reported as such in the literature. A careful scrutiny shows that a considerable percentage of the cases reported as abscesses are empyema communicating with the bronchus, subdiaphragmatic abscess rupturing into a bronchus, or circumscribed interlobar pleurisies.

Abscess—Etiology.—The most common cause of abscess of the lung is: 1, acute circumscribed inflammation, as pneumonia, followed by necrosis and softening of the lung, 46 per cent.; 2, peribronchitis; 3, septic embolism of the pulmonary artery, or a single branch of the bronchial (pyemic embolism), 3 per

cent.;[43] 4, rapid tuberculary caseation and necrosis, with secondary infection; 5, perforation of the lung by infection from malignant diseases of the esophagus and mediastinum; 6, subphrenic perforations into the lung with retention; 7, foreign bodies in the bronchi 11 per cent. (Tuffier); 8, infections following injuries; 9, suppurative inflammation around calcareous deposits, the latter either a sequence or a cause of the suppuration. From the above it will be seen that the pathology of abscess of the lung is as varied as its etiologic factors. Its clinical course, its treatment and its termination will vary with its etiology; what then concerns us most as surgeons is its diagnosis and treatment.

Symptoms.—The symptoms will vary also with the etiology; take, for example, an abscess following pneumonia. The case runs the ordinary course of a pneumonia; there is nothing special to indicate the probable necrosis and suppuration of the lung during the course of the disease till the time for resolution has presented itself; when the time has arrived for the cessation of fever, cyanosis, delirium and toxic symptoms the sudden change so characteristic of pneumonia does not take place. The fever continues with more marked morning remission and evening elevation. The hectic flush and sweats are more pronounced; the tongue remains dry, coated and cracked; in other words, the symptoms of pus infection have supplanted the symptoms of pneumonia. In some cases there is a sudden expectoration of a large quantity of pus in which may be found lung tissue and various micro-organisms, as pneumo-, strepto- and staphylococci, bacillus communis coli, etc. The expectoration is most frequently fetid, though not necessarily so. This fact aids materially in making a diagnosis. If the abscess be caused by a septic embolus, by a foreign body, perforation of the esophagus, etc., the history will vary from the above. Where it is produced by the suppuration of a cyst, as a hydatid the characteristics (hooklets) will be present; again, when a dermoid in the chest cavity suppurates and opens through a bronchus there will be found sebace-

[43] Porter: Jour. Amer. Med. Association, March 9, 1891.

ous material, hair or even teeth in the expectoration. (Ogle-Godlee.)

Physical signs and diagnosis.—The physical signs will vary with the size, location, presence or absence of bronchial communications and etiology; the presence of dulness, the absence of respiratory sound absence of cavernous breathing, the diminished vocal fremitus, the absence of intercostal movement in respiration, the stationary area of dulness, lead to the belief that there is an accumulation of fluid; a differential diagnosis must then be made between cysts, pleuritic effusion, gangrene, abscess, and consolidation. Inspection shows a marked loss of respiratory movement and occasionally signs of edema where the abscess is situated close to the chest wall. If it be deep in the lung the respiratory movements may not be interfered with. Percussion where the abscess does not communicate with a bronchus reveals a circumscribed dulness. If the abscess communicates with a bronchus we may get a cracked-pot sound, or the dulness may be the same as if non-communicative if the cavity is kept constantly full of pus. Great care should be taken in making comparison between the deep and superficial percussion notes to determine if lung tissue intervenes between the abscess and the chest wall; the area of deep and superficial dulness should be carefully outlined on the chest surface.

In auscultation the sounds will vary, depending upon the presence or absence of bronchial communication. There may be a superficial respiratory murmur with a deep abscess. The vocal fremitus is diminished. If the abscess be large, distant bronchial breathing can often be detected. When bronchial communications exist we have the amphoric breathing, often the distinct metallic tinkle, the whisper sounds and the gurgling. In pulmonary abscess and bronchiectatic cavities the stethoscopic examination is liable to be misleading as to their location, they often appear to be situated farther from the hilum than they are in reality. In my experience this was not true, as the percussion and auscultation revealed the location when the cavity was situated in the anterior portion of the lung.

Exploratory puncture has been considered the crucial test, although authors differ widely as to its value and significance as a negative manifestation. E. Bull considered it of only moderate value; still he insists that it should always be used where drainage is indicated. He attributes its deficiencies, 1, to failure in proper location of abscess by other physical signs and therefore not reached by needle; 2, to a plugging of the needle before the cavity is reached, and 3, to abscess contents being too viscid to pass through the needle. Tuffier says exploratory puncture is permissible but often deceptive, and when negative the puncture is to be made many times. In his cases he made from two to twelve punctures in each case and found with this large number of efforts he failed to locate the cavity in 17 per cent. of the cases of gangrene, 17 per cent. of the abscesses and 33 per cent. of the bronchiectases. He further states that puncture is harmless when done at the time of operation, but at other times may be dangerous; it is deceptive, as it does not show the multiplicity of the lesions. He found in twenty-eight cases that the primary exploratory puncture produced positive results in sixteen, multiple punctures added seven positive results to the number, and in five the result was negative. Foul gas in the syringe is just as positive, from a diagnostic standpoint, as pus. Bushnell favors repeated punctures for localization.

The dangers of exploratory puncture are: 1. Hemorrhage. In recalling our anatomy we are reminded that a blood vessel accompanies each of the bronchi; these are likely to be punctured in exploration, give blood in the hypodermic, and may be followed by fatal hemorrhage; a case is reported by Fraentzel. In two of my cases of bronchiectasis there was considerable blood expectorated after puncture, but not sufficient to cause alarm. 2. Infection of pleura. The literature supplies a number of cases in which the pleura became infected following exploratory puncture, either from the escape of pus through the puncture canal, or from an advancement of the process along the canal into the pleura subsequently, producing an infective pleuritis. 3. Gangrene. A

gangrene along the line of puncture involving the external chest wall has followed exploratory puncture, therefore exploratory puncture is not as harmless even in pleuritic adhesions as might be believed. 4. Pneumothorax. This has proved to be a serious complication following exploratory puncture only when accompanied by infection. I am convinced that exploratory puncture in the surgery of the chest, for diagnostic purposes, will not become a common procedure except for localization at time of operation.

Location of the abscess.—The abscess may be situated in any portion of the lung. Tuffier found it in the lower lobe in 80 per cent. of the cases and most frequently in the posterior portion of that lobe. With the aid of the radiograph we are able to determine if the abscess be close to the anterior or posterior wall of the chest, as can be seen from radiographs of Miss K.

Treatment.—After the diagnosis has been determined, should the treatment be palliative (therapeutic, pneumothorax, puncture with trocar or aspiration) or surgical (resection of chest wall with compression of lung over abscess, incision with drainage)? That will depend somewhat on the etiology and location of the abscess, but more particularly upon its size. Should there be an absence of adhesion and the lung collapse when the pleura is opened, and if the abscess communicates with a bronchus, it would seem from a theoretical standpoint that it should drain and close. Thoracotomy in this manner is so easily performed that it appears to me applicable in the class of cases in which pneumotomy is most dangerous, *i. e.*, where there is an absence of adhesions. It allows of, *a*, drainage through the bronchus; *b*, contraction of the cicatricial abscess wall; *c*, peripneumonic compression from the air in the pleural cavity. All of these should favor the repair of the abscess. We know from the results following operations for pyo- and hydrothorax that the lung after a long period of compression, re-expands and functionates; this point is most forcibly illustrated by the cases of Delagéniere. If pleuritic adhesions exist there can not be a general collapse of the lung; it would only be partial.

Puncture and aspiration as treatment for abscess of the lung has rapidly fallen into disuse. William Koch favored this procedure, as he feared pneumotomy. The treatment of suppurating cavities by means of aspiration in most positions in the body has been very unsatisfactory, and abscess of the lung is no exception to the general rule. The trocar and permanent canula have been advised and used in cases with adhesions, and particularly advocated when adhesions did not exist; the canula was intended to conduct the septic material across the pleural cavity to the opening in the chest wall. Dr. E. Fletcher Ingals[44] reports three cases treated by aspiration alone; all recovered. He states the diagnosis of abscess was not confirmed by microscopic examination and might have been circumscribed or interlobar pleurisy. Dr. McArthur, in discussing Dr. Ingals' paper, advocated operation with packing of pleura with gauze to protect the pleura when adhesions were absent. T. Anderson[45] successfully operated a case by first introducing a trocar, waiting two days and then dilating with artery forceps; there was no hemorrhage. Cummins[46] did a similar operation with recovery.

It would seem far preferable in these cases to make a large free opening in the chest by resection of the sixth, seventh and eighth ribs, pack gauze around the infected area, open the lung cavity and freely drain the costo-diaphragmatic cul-de-sac, as advised by Delagéniere for empyema.

The canula and trocar have been used with indifferent success in the treatment of pulmonary abscesses; while its inefficiency has not been so pronounced in abscess as in gangrene, the records show that it is far from satisfactory and not free from danger; in many cases secondary thoracotomy and pneumotomy had to be performed. A case forcibly illustrating this point is reported by J. Eustace Webb,[47] where an apparently perfect drainage through the canula ceased after six weeks; a few weeks later a

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44 Jour. Am. Med. Association, Vol. xxviii, 1896, p. 397.
45 Am. Prac. and News, Louisville, 1890, N. S. X., 10-12.
46 British Medical Jour., 1889, Vol. i, p. 299.
47 Lancet, London, June, 1895, p. 640.

pleurotomy had to be performed on the anterior side; patient recovered. H. Havelock Davies reports a successful case with the canula and trocar treatment.[48]

Bull, in 1884, urged that all abscesses should have artificial fistulæ established; that all cavities should be drained to prevent secondary results. He realized the difficulty of estimating the size of the cavity and differentiating between one large cavity and multiple closely allied small ones. He considered that tuberculosis was a positive contraindication to the establishment of drainage.

By an external physical examination we are unable in the great majority of cases to determine the presence or absence of adhesions. Occasionally a friction sound will be heard, which will indicate that there are no adhesions at that point. I have demonstrated that the absence of adhesions can be positively diagnosed. By introducing an exploring syringe trocar through the skin into the intercostal muscles; the stilette is then withdrawn and the trocar is connected with a filter bottle to which a bag of nitrogen gas or sterile air is attached; a slight pressure is placed on the reservoir and the trocar is pushed forward until the parietal pleura is penetrated; if adhesions do not exist the gas will suddenly commence to flow and the lung will collapse. On the other hand, if the lung be adherent, the trocar will traverse the parietal and visceral pleuræ and penetrate the lung and the gas will not flow. To illustrate:

Case 1.—Mr. K., clerk, age 24, Cook County Infirmary, admitted to hospital April 30. Suffering with tuberculosis of the right apex; physical signs extending down to the margin of the third rib in front; tubercle bacilli present. He was placed on the table and a puncture made with the trocar, as described above; when the parietal pleura was punctured the gas was seen to suddenly pass through the filter solution and soon the physical signs of pneumothorax presented themselves; 120 cubic inches were injected, proving absence of adhesions. The history of this case will be given in full in connection with the treatment of tuberculosis by defunctionalization.

Case 2.—E. L., male, age 34, Cook County Infirmary. Phthisis in second stage, with cavity in right upper lobe; the method was the same as was used in the preceding case; after the insertion of the trocar there was no escape of gas

[48] Lancet, London, Sept. 1, 1888.

until the lung was deeply penetrated, then it passed freely and was detected in the upper air passages; there was no collapse of the lung; no inconvenience was produced by the injection, showing that adhesions existed.

Bull considered it was not necessary to a good result in opening abscesses that adhesions should be present; this is also shown by the case of Kroenlein. One of the indications given by him for success, was that the cavity must be near the surface, and if adhesions were not present a trocar should be used to conduct the pus out of the pleural cavity. He advised the use of caustics to produce adhesions. This, however, had been advised previously by Krimer in 1830. Péan, in 1861, suggested suture of the visceral and parietal pleuræ for the production of adhesions before opening the abscess cavity. Barry and Graux also advised this method. Godlee suggested puncture for the production of adhesions. Mosley favored salicylic acid. Quincke urged zinc chlorid for the same purpose; Krause, a tampon. Quincke made fifteen experiments for the establishment of adhesions by suture; his results showed the method a failure.[49] Tuffier found adhesions present in 87 per cent. of the septic cases.

Tuffier,[50] in his most excellent paper, considers that the dangers are great where adhesions do not exist and that opinion was based on his experience in eight cases in which complete pneumothorax occurred during the operation; in two death was immediate; one died a few hours after the operation; two recovered (suppurating foci not opened); one recovered (focus opened four months later), and one with immediate opening of focus. The first three of these results appear to be attributable rather to the character of the opening than to the presence of a pneumothorax. From a perusal of the most recent cases reported and from my experiments I feel convinced that adhesions are not necessary to success, and furthermore that their absence has advantages, as then the entire hand may be inserted into the chest for the palpation of the lung and location of abscesses; further, I am convinced that abscesses without adhesions, and with

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49 Med. Week., Paris, 1895, p. 505.
50 Inter. Med. Cong., Moscow, 1897.

bronchial communications, should not be treated by incision and drainage through the chest wall, but by producing collapse of the lung by injecting nitrogen gas or a liquid into the pleural cavity, thus compressing the lung and allowing the connective tissue in the wall of the abscess to contract and obliterate the cavity with the aid of the bronchial drain.

Operation.—In abscesses of the lung the earlier the operation the better the prognosis (Sonnenberg) The incision in the chest wall should be the U or H shape which admits of an extensive resection and thorough exploration of the field in which the abscess is located. The ribs should be resected subperiosteally, if possible without opening the pleura. After the chest has been opened and adhesions found present, the location of the abscess must be determined; this may be accomplished with the exploring needle, with the scalpel, or, better still, by careful digital palpation. The lung may be pushed away from its parietal adhesions and a digital palpation made in every direction until the position of the abscess is determined, then the exploring needle may be used to confirm the diagnosis. The scalpel should be used to incise the lung and abscess wall. E. W. Andrews favors the scalpel, and successfully incised an abscess four inches below the surface of the lung and removed thirty-five grammes of calcareous material from the cavity. The hemorrhage is unpleasant but rarely dangerous, three serious cases having been reported, one by Quincke, and two fatalities, one each by Fabricant and Andrews. In the latter case no autopsy was permitted. The patient had several severe hemorrhages preceding the operation; it is presumable that the fatal hemorrhage was from the same source. The hemorrhage following the incision can be controlled by compression, or better, by accurate catgut suture. I found the latter more satisfactory in my experimental work. The scalpel is preferable to the cautery; it produces a clean incision; it allows of inspection of the tissues divided; it permits a view of the cavity when opened and a suture of the lung tissue for hemostasis if necessary; the cautery may be used on the incised surface to still the bleeding. There is,

however, with incision some danger from air embolus of the pulmonary vein, as the blood here may have a minus or a very feeble plus pressure, and in deep inspiration the air is aspirated into the vein. Quinke reported a fatal case of this character. Reclus favors the Paquelin cautery for opening the abscess. If the lung recedes after the division of the pleura the opening should be rapidly enlarged and the hand or cyst forceps inserted to draw the lung out. It can be retained here by sutures to the parietal wall and packed around with iodoform gauze. The lung in this position admits of accurate palpation and if the tampons are properly placed there should be little risk in the immediate opening of the abscess. A large drain of soft pure rubber should be inserted and secured by suture to the lung and chest wall; or, better still, rolled gutta percha paper or gauze drain may be used. The rubber drain has been charged with being the immediate cause of hemorrhage from pressure necrosis of the vessel wall. (Walsham and Sutherland.)

The irrigation of pulmonary cavities is rapidly going into disuse; it produces unpleasant symptoms and in one case caused a fatal result—laryngo bronchitis—boric acid and thymol having been used. H. W. Austin [51] reports a case in which irrigation with bichlorid was used without producing unpleasant symptoms, although the patient almost drowned from rupture of the abscess into the bronchus during operation. Case recovered.

Experiment 1.—Nov. 1, 1897; black dog, weight about 30 lbs.; right side of chest was shaved and rendered aseptic by scrubbing with soap, ether, alcohol and bichlorid 1-1000; ether anesthesia; usual antiseptic precautions with instruments, ligatures, towels, lap sheets, hands, etc.; an incision 3 inches long, over and parallel to the second rib was made; resected three inches of the latter; the pleura was incised for two inches; immediate collapse of the lung was observed; the vibrations of the mediastinal septum were watched and it was noted that with each inspiration it vibrated farther to the left and with each expiration farther to the right; it became thinner and thinner until it was a mere film and looked as if it would rupture; the attenuation took place anterior to the mediastinal contents; the dog became cyanotic and finally ceased breathing; the chest walls were then compressed and

51 Marine Hosp. Rep., Washington, 1889, p. 246.

the opening in the right side closed by the palm of the hand; when the chest expanded the dog began to breathe regularly and rapidly; his cyanosis quickly disappeared; when the hand was removed respiration would rapidly cease, when replaced it would go on as before; it appeared to make no difference whether the aperture were closed at the end of inspiration or expiration. The upper lobe was drawn out through the opening with the forceps; the apex was split with the scissors down $1\frac{1}{2}$ inches; the incision was closed by accurate continuous catgut suture; the lung was dropped back into the chest and the opening closed with a deep suture of muscle and fascia with catgut and a subcutaneous buried suture of the same material; the dog was not sick after the operation; as he absconded on the twelfth day I was unable to obtain the specimen, with which I wished to show the histology of repair of incision. The literature furnishes us many reports of repaired punctured and bullet wounds of the lung. The restoration is so perfect that it is often difficult or even impossible to locate the track of the missile from the pathologic evidence. I therefore did not repeat this simple experiment.

Prognosis.—Reclus reported 23 pneumotomies for abscess, with 20 recoveries and 3 deaths. J. Schwalbe† says that, of 50 per cent of the cases operated for acute and chronic gangrenous abscess recovered and 40 per cent. died. In chronic bronchiectatic and simple abscess only 16 per cent. recovered, 41 per cent. died. Of 43 cases collected by Tuffier there were 10 failures; in 7 per cent. of these the failure was due to inability to locate the abscess, from an inexact diagnosis or from the absence of adhesions. Fabricant reports 17 abscesses following pneumonia all operated, with 14 recoveries; 7 following infection, with five recoveries; 3 suppurating hydatids, all recovered; 2 gunshot wounds, both recovered; in all, 29 cases, with 24 recoveries. J. Blake White performed pneumotomy twice on the same patient at an interval of three months with success. Ramsay‡ reports four cases of pneumotomy. The ultimate results, when the abscess has been opened and drained, are favorable, particularly in the acute abscesses following pneumonia: the subacute or chronic heal slowly with prolonged or permanent fistulæ. The earlier the operation the more certain and rapid the healing, as the wall is thinner, the cavity usually small and the reparative process more rapid. I have collected 71

† Cent. f. Chir., vi. p. 171.
‡ Ann. Surgery, St. Louis, 1890, xi. p. 43.

cases of abscess of the lung; of these 49 completely recovered: 5 recovered with fistulæ; 16 died, 1 from the operation, 10 from undetermined causes, 3 from exhaustion, 1 from hemoptysis, 1 case was lost sight of.

Lung Abscesses from 1878 to 1897, years in rotation.

Case 1, 1878. Radsk, Centralblatt f. Chir., 1878, No, 44, p. 750. Male, aged 44 years. Two large abscesses in region of right mamma. Emphysema necessitatis, with communication with right bronchus; located in region of right mammilla; incision and escape of one liter of pus; irrigation with carbolic acid, followed by rise of temperature. In next few hours there was improvement. Death in 29 hours. Necropsy: Large abscess cavity in lower lobe and fresh pleuritis on opposite side.

Case 2, 1879. Austin, Rep. of Super. Surg.-Gen. Marine-Hosp. Service, Vol. 17, 1879, p. 246. Male, aged 21 years. Empyema and abscess of lung, duration 3 months. Had a cough. Located in left side; abscess in upper lobe of left lung; abscess probably communicated with pleural cavity. Aspirated several times about 1 month before operation; aspiration showed a clear fluid at time of operation; puncture almost pus. Incision 1½ inches long in axillary line between 9th and 10th ribs; rubber drainage tube inserted, 5 quarts of offensive pus escaped at once; 3000 c.c., 1-4000 HgCl. solution irrigated. Recovery, with persistent fistula.

Case 3, 1879. Sedgwick, Lancet, March 29, 1879, p. 441. Abscess of lung. Typhus. Puncture twice at short intervals.

Case 4, 1882. Fime, Norsk Mag. for Hæger, 1882, No. 22, in Runeberg obs. 4. Female, aged 4 years. Abscess of lung. Duration 7 weeks. Acute lobar pneumonia upper left lobe. Location, apex of left lobe in front. Incision in 2d or 3d intercostal space; pneumotomy; Pus had mixed with air; drainage. Slow recovery.

Case 5, 1882. Lancet, 1882, Vol. 1, p. 601, Payne. Male, 23 years. Abscess that had been diagnosed as purulent pleurisy. Acute inflammatory affection of lung (pleurisy). Located at base; adhesions. Puncture, axillary line; positive result. Incision, pleurotomy (venous hemorrhage); drainage. Temporary improvement; patient died seven days after. Necropsy: No pleurisy; abscess of lung; report not very precise.

Case 6, 1882. Quiss, Wiener Med. Woch.. No. 3, Vol. 3, 1882, p. 364. Male, middle aged. Abscess. Pneumonia; fluctuation on chest wall. Incision 1 cm. long in seventh interspace, large quantity of pus removed two hours after operation; great bleeding; gradual improvement. Dismissed in seven weeks cured.

Case 7, 1884. Rohden, Deut. Med. Woch., 1884, Vol. 14. Female, 20 years. Empyema and abscess of lung; duration two months. Left-sided pneumonia, on lower left side. Puncture at angle of sixth and eighth ribs, emptying 1100 c.c. of fetid pus. Thoracotomy on August 8; drainage and irrigation with salicylic acid sol.; fever diminishes and improvement sets in; on August 30 drain is removed, temperature now rises and patient becomes worse; the wound reopened, drain and finger introduced; abscess of lung is thus opened and pus escapes; continuous irrigation. improvement; after several months the fistula is healed.

Case 8, 1884. Pridgen Teale, Lancet, 1884, Vol. 2, p. 6. Male, 54 years, Pulmonary abscess cavity. Pleuro-pneumonia one month before. Location at base of right lung posteriorly; pleural adhesions. First puncture, serous liquid; second puncture, pus; two days after cavity punctured with trocar, fetid pus. Incision at right of puncture; pleural cavity contains no liquid; puncture of adherent lung yields pus; opening enlarged with finger, escape of two pints of pus; drainage, carbolized irrigation. Recovery; drain removed five months after. Patient seen three years after; some retraction of thorax and feeble respiratory excursion on right side; later patient had two operations with death.

Case 9, 1884, Waugh, quoted by Tabucaat. Male, 53 years. Abscess of lung; acute pneumonia of left lung. Resection in ninth intercostal space; profuse hemorrhage, checked by tamponade. Good and complete recovery.

Case 10, 1885. Broadlett, Med. Jour., May 31, 1884. Large cavity in lower left lobe, which was opened, followed by slight improvement. Cavity opened. Death.

Case 11, 1885. Andrews, Jour. of Am. Med. Assn., 1885, Vol. 5, p. 261-265. Male, 28 years. Abscess of lung. Located left side posteriorly. Signs of cavity. Puncture between fourth and fifth ribs, no result; second punc-

ture in anterior chest wall, finds pus. Incision on needle, no rib resection; large amount of fetid pus escaped; irrigated with carbolic solution. Recovery rapid and complete.

Case 12, 1885. Korobein, 1885, quoted by Fabricant. Female, 11 years. Abscess of lung and empyema. Located in left lung. Positive puncture. Resection after eight days' drainage; after seven months wound made larger. Recovery.

Case 13, 1886. Bouilly, 1886, quoted by Fabricant. Male, 46 years. Cavity in upper right lung. Ecchinococcus removed 10 years ago by expectoration. Located in upper right lung; pleural adhesions. Resection of 6.7 cm. from third and fourth ribs; pneumo-cautery used. Recovery; left on eighteenth day.

Case 14. 1887. Hassen, Mamg. Disoeft, Kiel, 1886, et Berlin Woch., 1887, Obs. du Quincke, p. 138. Female. Old pulmonary abscess or broncicctasis. Duration twelve years. Pulmonary affection of undetermined nature; base of left lung. Signs of cavity; no adhesions. Exploratory puncture axillary line, negative; five injections of one-fourth or one-half tinct. of iodin; second puncture at same point yields a few drops of very fetid pus. Died three weeks after of purulent pleurisy.

Case 15, 1886. Rocket, 1886, Wid. Abscess, Resection. Recovery.

Case 16. 1886. Wiener Mer. Med. Presse, 1886, p. 1235. Male. Chronic abscess; base of right lung; pleural adhesions. Incision in sixth intercostal space; pneumotomy and drainage. Death eight days after, abscess communicating with abscess of liver.

Case 17, 1887. Quincke, loc. cit., p. 20 and 21. Obs. 2 at Berlin Klin. Woch.. 1887, p. 337, et in hassen loc. cit. Male, 26 years. Chronic abscess; pneumonia two years before, base of left lung posteriorly. No signs of cavity; no adhesions. Incision: zinc cl. 2 paste, in ninth intercostal space, repeated several times; resection of 4 cm. of ninth rib; puncture incision with thermo-cautery; treatment lasted three months. Pus is voided by wound for three weeks after operation; recovery with fistula. Saw case twelve years after; has a fistula which secretes a little.

Case 18, 1887. Runeberg, Deut. Archiv. 3, Klin. Med., 1887, p. 91. Male, 33 years. Acute abscess; five weeks; chronic pneumonia; base of right lung beneath spine of scapula. No signs of cavity; adhesions; exploratory puncture. Resection of sixth rib on axillary line; incision of a superficial abscess; irrigation with carbolic and drainage. Recovery in two and a half months.

Case 19, 1887. Thiriar, Bull. Acad. de Med. de Belgique, 1887, No. 10. Male, 22 years. Pulmonary abscess, hemoptysis; base of left lung posteriorly; adhesions; two negative punctures. Resection of fifth, sixth and eighth ribs, large resection; horizontal incision extending from 15 cm. of axillary line to angle of vertebral column along eighth rib; a vertical incision 5 cm. from vertebral column; opening of cavity with thermocautery. Recovery.

Case 20, 1887. Zieluvitz, Deut. Med. Woch., 187, Vol. 13, p. 239. Male, 15 years. Empyema; abscess of lung found at operation for empyema. Morbid pneumonia, three months later an empyema was found; lower left lobe. Resection of sixth and seventh ribs, exudation cleaned out; irrigation; abscess cavity opened along fistulous tract through empyema, incision; opening tamponed with iodoform gauze; empyema cavity tamponed. Patient cured in eight weeks.

Case 77, 1887. Zieluvitz, Deut. Med. Woch., 1887, Vol. 13, p. 239. Male, 15 years. Empyema with abscess of lung; abscess of lung healed was found at operation for empyema; a few weeks before empyema was opened. Seventh rib resected at a second operation for the empyema; cavity was cleaned out; healed abscess cavity was discovered. Recovery complete in six weeks.

Case 21, 1888. H. N. Davis, London Lancet,, Vol. 2, 1888, p. 419. Male, 21 years. Abscess of lung. Duration from beginning of sickness, about three years. Subacute pneumonia of left side, a year later consolidation of right lung; right side. Signs of cavity. Positive puncture in fifth interspace; anterior axillary line. Incision, upper border of sixth rib; trocar and canula introduced, a quantity of fetid pus removed; cavity washed out twice daily with carbolized col. for three weeks. Recovery; one and one-half months after operation cavity was closed; patient completely recovered and well and at work five months after.

Case 22, 1888. Godley, Brit. Med. Jour., 1888, Vol. 2, p. 880. Abscess; no adhesions. Suture of the two pleurae, pneumotomy. Death three days after from abscess of other lung.

Case 23, 1888. Quincke, loc. cit., pp. 6 and 7, Tab. 1 a, Obs. 5. Male 32 years. Acute abscess. Duration, four weeks. A typic pneumonia ten

weeks before; base of right lung posteriorly. No signs of cavity; no adhesions. Paste of zinc cl. 2, in eighth intercostal space; resection of 5 cm. in eighth and ninth ribs; new application of zinc cl. 2 paste nineteen days after exploratory puncture; abscess opened with thermo-cautery, 600 c.cm. of pus removed; treatment had lasted five weeks. Complete recovery in four months.

Case 24, 1889. Cummins, A., British Med. Jour., 1889, Vol. 1, p. 299. Female, 32 years. Abscess of lung; hemoptysis. Duration, six months. There was dulness of clavicular and infra-clavicular regions of left lung; increased vocal fremitus; fluctuation between eighth and ninth ribs on axillary line. Oblique incision, two inches in length, over eighth and ninth ribs, a dram of pus evacuated by means of probe; an opening was found between ribs, this was dilated by forceps and fingers; 3-4 oz. of fetid pus escaped; air passed in and out of cavity with respiration and expiration; pus discharged freely, lost fetor expectoration diminished; finger inserted every two or three days. Recovery. Patient began to improve and left hospital; re-admitted a few months later and died.

Case 25, 1889. Delpratt, Brit. Med. Jour., Vol. 1, p. 470. Male, 33 years. Abscess of lung. Calculus, pyelo-nephritis; base of left lung; adhesions. Pneumotomy without costal resection; drainage. Drainage tube removed at the end of three months; recovery in six months.

Case 26, 1889. Mosetig Moorhoff, Wiener Med. Presse, 1889, p. 1. Male, 22 years. Abscess following a traumatic fistula. Duration three years. Cause gunshot wound of chest. base of left lung; adhesions. Incision; three months before operation had resected fourth and fifth ribs; diagnosis, an empyema; pneumotomy enabled the operator to remove three fragments of ribs located in the parenchyma. In seven days wound was nearly healed, then Jacksonian epilepsy appeared which proved fatal three weeks after the operation.

Case 27, 1889. Selby, Brit. Med. Jour., Vol. 2, p. 766. Male, 26 years. Pulmonary abscess; axillary line right side at level of fifth rib; no signs of cavity at time of operation; adhesions. Two negative exploratory punctures; third puncture below preceding strikes pus. Resection of one and one and one-half inches of fifth rib; no pus in pleural cavity, lung hard and congested; abscess was not incised. Fetid expectoration, signs of cavity at base of right lung; recovery.

Case 28, 1889. Jonq. Reder, Tyds i, 13, 1889, in Quincke Witt aus greozgeb, 1895, 1 obs., pp. 6 and 7. Male, 33 years. Acute abscess, lasting several days; pneumonia on fifteenth day; base of left lung. Signs of cavity; pleural adhesions. Exploratory puncture; positive aspiration, lavage injections of iodin; abscess 5 cm. below surface. Recovery.

Case 29, 1890. Herbert Hawkins, Lancet, 1890, Vol. 2, p. 1330. Male, 14 years. Abscess, expectoration fetid; duration three weeks; pneumonia; left axillary region. Signs of cavity; adhesions; there was a consecutive purulent pleurisy. Positive puncture, pus at depth of 5 or 6 cm. Incision without costal resection; adhesions; pneumotomy; drainage. Recovery, but two days after patient had purulent pleurisy; empyema. Recovery in seven months.

Case 30, 1890. Hoffman, Deut. Med. Woch., 1890, p. 1156. Male, 24 years. Fetid metastatic abscess; duration, several weeks; otitis media and pyemia; base of right lung posteriorly. No signs of cavity; adhesions. Positive exploratory puncture. Costal resection; pneumotomy; drainage. Recovery in seven months.

Case 31, 1890. Liedaird, Lancet, 1890, Vol. 1, p. 964. Pulmonary abscess; two and one-half months; pulmonary affections undetermined; left base axillary line. Signs of cavity; adhesions. Exploratory puncture in fifth intercostal space; positive. Incision at level of puncture; resection of sixth rib, flow of pus; dilatation of wound cavity covered with calcareous masses; irrigation with boric acid produces coughing spells. Died five days after from hemoptysis. Necropsy: cavity size of goose egg, no bronchial communication, recent tuberculosis.

Case 32, 1890. Ramsay, Obs. 3, Annals of Surg., 1890, Vol. 6, p. 34. Female 17 years. abscess. Duration, one month; Measles and pneumonia one month before; to left. Signs of cavity. Resection of third, fourth and fifth ribs, opening of cavity with thermo-cautery, tamponing. Septicemia in two months; death. Necropsy: Ramsay says there were multiple abscesses.

Case 33, 1890. Ramsay, Obs. 4, Annals of Surg., 1890, Vol. 6, p. 34. Abscess; few months duration; typhoid fever; inferior lobe of right lung. Resection of third, fourth and fifth ribs under median line; pneumotomy with thermo-cautery, little pus escaped, tamponing. Perfect recovery; patient has been able to resume work.

Case 34, 1891. Green, Lancet, 1891, Vol. 1, p. 193. Male, 6 years. Acute abscess; eight days' duration; pneumonia of five weeks' standing; base of left lung. Puncture in fifth intercostal space in axillary line. Incision: pneumotomy on trocar. drainage. Recovery in twelve days.

Case 35, 1891. Huber, Med. News, 1891, Vol. 59, p. 455. Male, 4 years. Acute abscess; six weeks' duration; pneumonia; left summit forward. No signs of cavity; adhesions. Incisions in third intercostal space without costal resection; exploratory puncture confirmative, dilatation of puncture, drainage. Recovery in eight months.

Case 36, 1891. Indiania, Med. Gazette, 1891. Calcutta in Morillon, These Paris, 1897, p. 5, des Tableaux. Male, 35 years. Abscess of lung opened and fistula; fistula going from below up back toward axilla; four months' duration. Located at base of right lung posteriorly; adhesions. Resection of eleventh rib posteriorly; hemorrhage from intercostal artery, three ounces of fetid pus; irrigation with bichlorid of Hg. Recovery with retraction of thoracic wall.

Case 37, 1891. Terriet, Soc. de Chirurgie, 1891, p. 741; Morillon, Paris, 1897, p. 62. Abscess of lung, secondary to liver abscess that has opened in the bronchi; one year's duration; liver abscess dysenteric; located at base of right lung posteriorly. Signs of cavity; adhesions. Puncture behind in axillary line posteriorly, in eighth interspace; escape of pus. Resection of eighth rib; drainage of abscess; improvement, but accidents of retention cause symptoms of gangrene thirteen and a half months afterward; new resection of eighth rib; incision of lung; this incision leads into a dilated bronchus; curretement of this bronchial dilatation. Complete recovery; patient seen two years after recovery, he is a navy surgeon and can resume his work.

Case 38, 1892. Andrews, Chicago Med. Rev., 1892, Vol. 3, p. 537. Male. Abscess of lung, several years' duration; recurrent pneumonia; cavity of middle lobe; pleural adhesions. First puncture negative, second puncture under chloroform entered cavity at depth of 7 to 18 cm. Incision, trocar inserted in the sixth interspace; pneumotomy; amelioration four months later because of retention; thorocoplasty was made; resection of third, fourth, fifth and sixth ribs in the axillary line opening of a large cavity containing calcareous débris. Recovery with fistula. Death four and one half years later from acute broncho-pneumonia.

Case 39, 1892. Ricard in Record Gazdezhop of 1892, Maus et Soc. Chir., 1895, p. 689. Male, aged 36 years. Suppurative interlobular pleurisy of left lobe or abscess of lung. Several months; pleuro-pneumonia; traumatic of three months standing; right axillary region; no signs of cavity; adhesions; eleven negative and one positive puncture. Resection of fourth rib on axillary line of seventh and eighth ribs on a level of last puncture; exploratory puncture; opening of cavity with thermo-cautery; cavity was 2^1_2 cm. below surface tamponing. Rapid improvement; recovery without fistula in thirty-four days.

Case 40, 1893. Fairchild, Chicago Clin. Rev. Vol. 9; No. 93 in Wein. klin. Woch., 1893, p. 633. Male, 55 years. Abscess of lung. Pneumonia. Location, base. No signs of cavity; adhesion. Repeated negative punctures; at last a positive puncture in fifth intercostal space. Incision in fifth intercostal space on trocar section of 2 cm. of fifth rib; pneumotomy; abscess containing eleven ounces of pus; drainage; irrigation; no coughing spells. Uneventful recovery in one year.

Case 41, 1893. Huber, Arch. of Baldiatrue, Vol. 10, 1893, p. 1006. Age, 13^1_2 months. Acute abscess. Acute lobar pneumonia. Located at base of left lung. No signs of cavity; adhesions. Two positive exploratory punctures in third intercostal space. Incision upon a trocar as psoas; pleuro-pneumotomy; one and one-half ounces of pus; drainage; abscess communicates with bronchus. Rapid recovery.

Case 42. E. F. Ingals. Jour. Am. Med. Assn., Vol. 27, p. 397. Female. aged 40 years. Abscess of lung. Liver abscess. Located in lower outer cover of right mammary region. Postive puncture; fistula left along needle. Five months after first seeing of patient portions of two ribs resected; lung tissue penetrated and abscess cavity opened; cavity communicated with liver abscess and bronchial tubes; drainage tube. Failed after operation; died in three weeks.

Case 43. E. F. Ingals, Jour. Am. Med. Assn., Vol. 27, p. 397. Male, aged 36 years. Pneumonia. No positive signs of a cavity. Punctured between seventh and eighth ribs near angle: positive; drew off offensive pus; another positive puncture six days after the first; third punture negative. Recovery.

Case 44, 1893. Mouson, A., Lancet, Vol. 1, 1893, p. 1196. Female, aged 32 years. Thrombosis of lung or mediastinal abscess discharging through

lung. Duration, five months. Sickness dated from child-birth, about five months before; slight cough before that. Location, right posterior apex. Signs of cavity. Incision in right interscapular region; after piercing third right intercostal space, near angle of ribs, small quantity of pus. Patient died twenty days after operation. No necropsy.

Case 45, 1893. Tizebicky, Wien. klin. Woch., 1893, No. 2, 1722. Female, aged 42 years. Pyemia abscess, duration fifteen days. Peurperal infection of two months' standing. Location, base of right lung posteriorly. No pleural adhesions, Punctured; 500 c.c, of pus. Resection of seventh rib three days after incision; pneumothorax, Death ten hours after. Autopsy: No pleural adhesions; serous pleurisy in stage of resolution; operation in extremis.

Case 46. Chuston by Littlewood, Brit. Med. Jour., 1894, Vol. 1, p. 69. Aged 12 years. Two small pulmonary abscesses. Resection of two ribs; pneumotomy, Recovery.

Case 47, 1894. Delageniere, Arch. Provenciales da Chirurgie, 1894, Janeviei. Female, aged 37 years. Lung abscess; pneumonia; pleural adhesions. Pneumotomy after resection of sixth, seventh and eighth ribs. Recovery; maintained no fistula.

Case 48, 1894. Kasauli, in Fabricant Chir. Vieshnik, 1894, p. 763, Obs. 29. Male, aged 36 years. Abscess of lung; duration, eighteen months. Gunshot wound of chest eighteen months before; base of left lung; adhesions. Incision at time of accident; incision of second and third ribs; persistent fistula; accidents of retention and of septicemia necessitating, eighteen months after, a pneumotomy; eighth rib resected; opening of an abscess. Recovery but still had a fistula forty days after.

Case 49, 1894. Neuber, Mittheil d. Veseius Schleswig Holstein Aerzte, 1894, p. 55, in Quincke loc. cit., Tab. 11a, pp. 20 and 21. Male, aged 45 years. Chronic abscess of eight months' duration. Calcareous concretions in bronchi; base of right lobe posteriorly. Signs of cavity; no adhesions. Resection of eighth, ninth and tenth ribs; 18 cm.; pneumotomy six days after; 500 grains of pus and calcareous concretions. Recovery with persistent fistula; patient is alive four and one-third years after; general good health; however, there persists a fistula and a cavity the size of a fist secreting a mucus liquid; bronchi open in this cavity.

Case 50, 1894. Rochester Med. News, 1894, in Morillon Th. Paris, 1897, p. 96. Male, aged 15 years. Pyemic abscess of a few days. Appendicitis operated on twenty-seven days before. Location, base of left lung, posteriorly. Signs of cavity. Resection of 6 cm. of sixth rib on posterior axillary line; pneumotomy; 8 c.c. of sanguinal pus; drainage. Improvement twenty-three days after, wound healing; no more signs of cavity.

Case 51, 1894. Matequon, Arch. gen. de Med., 1894-2-1, p. 162. Male, aged 22 years. Chronic abscess; hemoptysis; profuse expectoration; one and one-half years duration. Acute pneumonia. Location, right apex, forward; signs of cavity; ancient and firm adhesions; two negative exploratory punctures a long time before operation. A resection of 4 cm. of second rib; positive exploratory puncture; incision with thermocautery of 5 cm. of pulmonary parenchymia; a cavity opened; accidents of retention four days after second pneumotomy, after negative puncture at base of first cavity, Recovery after relapse, which necessitated a third pneumotomy; several hemoptyses; profuse expectoration; cicatrization in three months. Patient seen in six months after in good health.

Case 52, 1895. Berger, Soc. de Chir., 1895, p. 716. Abscess of the lung. Rib resection; pneumotomy with a cautery; incision 4 cm. in depth; no abscesses found, but the hemorrhage necessitates a tamponade and suspension of operation. Death several days after. Necropsy: The pulmonary incision is found just between two purulent cavities.

Case 53, 1895. Soc. de Chir., 1895, p. 733, Monod. Male, aged 35 years. Abscess at base of lung. Signs of cavity; adhesions. Resection of the seventh and eighth ribs; pneumotomy; cavity located higher up than had been thought; opened with thermo-cautery after two exploratory punctures; it had the volume of a walnut. Recovery.

Case 54, 1895. Quincke, Mittheil aus Zrenzgeb der Med. Chir.. 1895, p. 1; loc. cit., pp. 6 and 7, Tab. 1, Obs. 7. Male, aged 23 years. Acute abscess three weeks after onset; profuse expectoration and hemoptysis; later bloody expectoration; nine weeks' duration. Pneumonia twelve weeks previous. Location, base of left lung, posteriorly; no signs of cavity. Incision: Application of ZnCl. 2 paste in ninth rib intercostal space; eighteen days after resection of ninth rib, exploratory puncture; no cavity is found. Complete cure in six weeks; rapid retraction of thoracic wall.

Case 55, 1895. Quincke, Mittheil aus Zrenzgeb, 1895, dd. a. B., p. 1. Male, aged 33 years. Acute abscess of lung; two months duration. Pneumonia

due to aspiration of mud. Location, base of left lung; no signs o cavity. Puncture; 300 c.c. of serous fluid. Sudden death ten days after puncture. Necropsy: Sero-purulent pleurisy and primary abscess of lower left lobe, opening into pleura bronchi; ectasis and cicatrix of a healed abscess situated above first mentioned abscess; right-sided pneumonia.

Case 56, 1895. Ricard, Soc. de Chir., 1895, p. 689. Pyemic abscess mistaken for interlobular pleurisy. Location, base, posteriorly; no signs of cavity; partial adhesions. Resection of 10 cm. of eighth rib; incision; partial pneumothorax; abscess located higher and in the lung; is incised and drained. Recovery.

Case 57, 1895. Tuffier, Soc. de Chir., 1895, p. 766, Obs. 2. Male, age not given. Lung abscess; pneumonia. Incision without costal resection; complete pneumothorax focus could not be opened. Pyepneumothorax which was followed by empyema. Death one year later. Necropsy: Purulent pleurisy and abscess not opened.

Case 58, 1895. Valton, Belgique Medicale, 1895, Vol. 2, p. 545. Male, aged 13 years. Abscess of lung; lung cavity; fetid expectoration; eighteen months duration; pneumonia. Location, base of right lung. Resection of the seventh, eighth and ninth ribs; lung apparently normal after several negative punctures had been made; pus was found; pneumotomy with thermo-cautery; after suturing lung to pleura partial cleansing of cavity; drainage. Death twenty days after from exhaustion.

Case 59, 1895. Webb, J. E., London Lancet, Vol. 1, 1895, p. 1140. Female, aged 27 years. Abscess of lung. Duration, one month. Maternal history of phthisis inflammation of lung in early childhood. No physical signs of cavity. Puncture; anterior axillary line, sixth interspace; twelve ounces of pus removed. Trocar and canula inserted into cavity just above angle of scapula, between it and vertical column, directed forward and outward; fourteen ounces of pus removed; drainage tube passed through canula; iodoform injected. Two months after operation discharge ceased; two and one-half months later fluctuation was detected in the fifth interspace below the nipple; incision made and pus evacuated; this sinus closed in a few days; ultimate recovery.

Case 60, 1896. Bushnell, Am. Jour. of Med. Sci., 1896, Vol. 112, p. 298. Male, aged 36 years. Abscess of the lung; interlobular pleurisy; several weeks' duration. Acute pneumonia; location, base; partial adhesions; three positive punctures in sixth interspace. Incision; in sixth interspace no adhesions at this level; partial pneumothorax without gravity; puncture of lung; pus is immediately under the visceral pleura. Rapid disappearance of pneumothorax; six punctures parietal and five punctures a little later. Completely cured; abscess discharged into bronchi; recovery in seven months.

Case 61, 1896. Esquerdo, Rev. de Cien. Med. de Barcel., 1896, Vol. 22, pp. 244-250. Male, aged 42 years. Lung abscess; pain in side and dippuella cough; expectoration profuse; at first purulent, later putrid; slight hemoptysis; fourteen months duration. Exposure to cold; sailor. Right lung; signs of cavity; no pleural adhesions. Incision above seventh right rib, extending backward to axillary line; resected 10 cm. of rib; sutured lung to parietal pleura; explored with finger; induration found; thermocautery tip introduced into induration; cavity found and contents evacuated; packed with iodoform gauze; fourth day, cavity washed with warm boric acid; it came through into wound; solution came through into mouth; irrigation repeated many times; after eight days drainage tube put in. Cough and expectoration became less after operation; cavity became swollen; at end of forty days, no discharge from tube and patient has no cough or expectoration; four days after this he had a slight hemoptysis; ultimate recovery.

Case, 62, 1896. Luther, Australian Med. Gaz., 1896, Vol. 15, p. 344. Male, aged 37 years. Lung abscess opening into a bronchus; duration, six weeks. Chill and pain in left side; located in left lung; no positive sign of cavity; pleural adhesions. Incision over seventh rib; center of incision midway between spine and wound in axillary line; part of seventh rib resected; adherent pleura; lung easily broken down by finger; one-half pint of pus and debris; cavity douched with 40 per cent of creolin; drainage. Recovery; great relief. Cough and expectoration ceased; night sweats did not recur; temperature fell to 100, then to normal five days after operation; gained strength rapidly; perfect recovery.

Case 63, 1896. Sims, Med. Rec., 1896, Vol. 49, p. 500. Lung abscess. Incison and drainage. Recovery.

Case 64, 1897. Andrews, in Morrillon de Paris, 1897, p. 71. Male, aged 17 years. Lung abscess; duration several months; location, base of left lung; pleural adhesions. Puncture, 500 c.c. of pus. Resection of second rib,

posteriorly; pneumotomy; enlargement of the puncture wound. Rapid recovery; seen sixteen years later; cured.

Case 65, 1897. Andrews in Morrillon de Paris, 1897, p. 72. Female, aged 35 years. Abscess of lung; several months duration. Angio-cholecystitis; cholecystenterostomy after mercury. Location, right lobe, posteriorly; no signs of cavity; pleural adhesions. Punctures of lung and liver negative. Resection of two inches of seventh rib posteriorly; puncture negative; trocar inserted in all directions; at last reached a purulent cavity internally close to the vertical column; pneumotomy with cautery; 150 c.c. of pus. Recovery in ten months.

Case 66, 1897. Carl Beck, N. Y. Med. Jour., 1897, Vol. 66, p. 207. Male, aged 31 years. Duration, three months. Pneumonia when 10 years of age; in November, 1895, pleuro-pneumonia followed by cough and fetid expectoration. Location, right side anteriorly and below; signs of cavity. Incision over ninth rib from post axillary line to transverse process of ninth dorsal vertebra after right eighth and tenth ribs were resected; pleura was packed with aseptic gauze; needle pushed into lung; cavity entered; offensive pus aspirated with needle; opening dilated and packed with gauze. Considerable cough and expectoration after operation; patient improved rapidly; wound closed two months after operation.

Case 67, 1897. J. Curnow, London Lancet, 1897, Vol. 2, p. 1188. Male, aged 37 years. Empyema and abscess of lung; twelve days duration. Acute pneumonia; apex of left lower lobe; signs of cavity not certain; pleural adhesions. Positive puncture below angle of left scapula; twenty-four ounces of odorless pus removed. Incision in eighth interspace, median axillary line; twenty-four ounces of pus removed; drainage tube. Patient died next day. Necropsy: Right lung showed congestion and bronchitis of lower lobe of left lung; adherent pleural pneumonia abscess; cavity 2 cm. from apex, posteriorly.

Case 68, 1897. Edwards, London Lancet, Vol. 2, 1897, p. 1583. Female, aged 21 years. Lung abscess of two months duration; pleuro-pneumonia of right side; no positive signs of cavity. Puncture in the eighth interspace below angle of right scapula; two and one-half to three inch cavity was revealed; offensive pus; incision two and one-half inches long over ninth rib below angle of scapula; one inch of ninth rib resected; trocar and canula put into cavity and opening enlarged with finger and forceps; rubber drainage tube. Marked improvement; three days later temperature increased and condition was critical; one week after operation improvement again took place. Perfect recovery six weeks after operation; wound closed.

Case 69, 1897. De M. Moir, London Lancet, Vol. 1. 1897, p. 105. Male, aged 34 years. Liver abscess ruptured into the lung; liver abscess had existed about ten months. Etiology: Malarial perineal abscess and gonorrhea; obstructed liver abscess breaking into lung. Location, right lung in axilla; signs of cavity. Liver abscess incised and drained through the sixth interspace about two months before lung abscess was opened; mass far back in right axilla over fifth rib; one inch of fifth rib resected; counter opening in front in fourth space below nipple, opening up a secondary cavity which communicated with the first, also with liver abscess; drainage tubes in both incisions; taken out after seventeen days; wound closed rapidly. Discharge and expectoration diminished. Gradual improvement and ultimate recovery.

Case 70, 1897. Routier, Soc. de Chir., 1897, p. 138. Lung abscess; no signs of cavity; pleural adhesions. Pneumotomy after costal resection. Patient getting better when observation was reported.

Case 71, 1897. Ballington, Arch. Gen. de Med., 1887, Vol. 20, p. 465. Male, aged 6 years. Pleurisy and lung abscess. Pneumotomy; drainage of pleuro and abscess cavity. Recovery.

Case 72. Maydill, Jour. Amer. Med. Assn. Male, aged 29 years. Lung abscess of one month's duration; rupture of lung, posteriorly; signs of cavity; partial pleural adhesions. Resection of rib over area of dulness, near angle of scapula; cautery used to open cavity; escape of fetid fluid; masses of gangrenous lung discharged. Pulmonary edema and pneumonia of sound lung followed recovery. Cavity slowly diminished in size.

Bronchiectasis.—A dilatation of a bronchus may be cylindrical or ampullar, local or diffuse. (Grawitz.) Etiologically it may be a congenital defect or anomaly. (Welch.) It may be intrinsic, the result

of inflammation, necrosis, softening and dilatation, with retention of secretion in the bronchi; extrinsic, the result of contraction of the lung tissue or pleuritic adhesions. The ampullar variety when localized is the one which concerns the surgeon. The universal bronchiectasis, or the entire involvement of the bronchial tree (Osler), should not be treated surgically. Habershon [52] reports autopsy with multiple gangrenous bronchiectases of all lobes of both lungs. Pathologically the wall of the bronchus may be attenuated and its mucosa lined with pavement epithelium; more commonly it is ulcerated, with the lung tissue in the neighborhood involved in an inflammatory infective process. As surgical bronchiectasis is secondary to other pathologic conditions its symptoms are usually intermingled with those of the original disease. In the ampullar variety, however, the cough and expectoration are distinctive. The patient will pass many hours without coughing, followed by a violent attack with the expectoration of several drams or even ounces of a grayish, purulent fluid, with a sour and sometimes fetid odor; the microscope reveals crystals of fatty acids, occasionally those of hematoidin, and in tubercular cases bacilli. The physical signs are those common to cavities; exploratory puncture gave positive results in 50 per cent. of the cases reported. (Terrier.) Endeavor has been made to disinfect and medicate cavities of this class through inhalation. This up to the present has not been very successful. Hesse, of Schwartzenberg, showed that dust does not reach beyond the third division of the bronchus. Dr. Homer W. Thomas has made some excellent and interesting experiments in this line; he showed that vapors were carried into the alveoli themselves and demonstrated in one of the cavities on which I operated that the cavity could be filled with a sterilizing vapor.

Operation.—The sacculated is the only variety that admits of surgical treatment, and in this we have again the difficulty of differentiating between a number of small cavities closely situated and a large cavity. This was illustrated in a case to be related subsequently. The great obstacle in the surgical

[52] Lancet, London, April, 1894, p. 1012.

treatment of this class of cases is our defective localization, and while the radiograph shows distinctly the outline of large cavities it is not yet practical with small ones. Operation should be the same as that performed for abscess, though not more than two ribs should be resected. Adhesions were present in 84 per cent. of the cases operated. Digital exploration of the lung may aid in the localization of the cavity. The exploratory needle is also of service; when located the scalpel should be used to open the abscess and the cavity should be tamponed with iodoform gauze. Osler [53] cites a case of death following the operation for bronchiectasis with fetid bronchitis. Hofmokl [54] strongly favors the opening and drainage of these cavities and reports 42 cases, 14 cures, 3 fistulæ, 24 deaths, 1 result unknown. The results of operations in this class of cases have been very unsatisfactory. Roswell Park [55] collected (including Truc's) 23 cases with 9 deaths. Of 38 cases collected by Tuffier there were only 9 cures; certainly not a tempting inducement for incision and drainage. Leser,[56] of Halle, favors this operation. I have collected histories of 44 cases of bronchiectatic cavities that were operated upon; of these 25 recovered, 19 died. Of the 19 deaths, 11 were from undetermined causes, 1 from chloroform syncope, 1 from acute bronchitis, 2 from collapse, 3 from brain abscess, 1 from hemorrhage. We will await with interest the results of local compression after the removal of the thoracic wall as a treatment for this class of cases, as well as the results from artificial pneumothorax either of which I believe is preferable to drainage.

Case illustrating local compression, referred by Drs. Homer W. Thomas and Geo. W. Johnson: Maggie C., aged 48, admitted to Cook County Infirmary October, 1897, suffering from pulmonary tuberculosis; bacilli demonstrated; evening temperature, 102-103°. Physical examination reveals consolidation of both apices; râles universal; amphoric respiration demonstrated in left upper lobe anteriorly; the cavity is apparently large, extending from the first interspace to the third in the anterior axillary line, and having a transverse diameter of about three inches; the most pronounced signs

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53 Johns Hopkins Hospital Bulletin, Baltimore, 1889-90, Vol. i, p. 109.
54 Wien. Klin. Woch., 1893, vi. p. 68.
55 Ann. Surg., St Louis, 1887, v. 385. 56 Lancet London, March 9, 1891.

are at the lower margin of the second rib; there is also evidence of a cavity in apex of left lower lobe posteriorly. The belief was that the cavity was very large.

Diagnosis.—Bronchiectatic cavities (tubercular).

Operation.—November 14, 1897, resection of three inches of the second rib, left side, without opening the pleural cavity; found pleura adherent; Paquelin cautery was used and a small cavity the size of a walnut was opened; this was packed with iodoform gauze and the lung was compressed. The patient was in good condition on the table; six hours after the patient's temperature dropped to 95°, pulse became extremely weak and 160 beats a minute. Active stimulation was resorted to and in eight hours she rallied perfectly. The packing was not disturbed for three days, when it was removed; it was thoroughly saturated with pus and blood. The dressing was changed daily thereafter. The quantity of discharge was excessive at first and gradually diminished; the daily temperature was 102° in the evening and gradually dropped from that until it reached 90°. The improvement, diminution of discharge, increased appetite and lowered temperature continued for about three weeks. The temperature began to rise; the night sweats reappeared, the expectoration rapidly increased, evidences of the formation of cavities in the right lung appeared and the patient grew rapidly worse. The cavity in the left lung was granulating and the discharge had almost ceased. The patient died rather suddenly on December 15, having shown no signs of approaching dissolution to within half an hour of her death.

Postmortem revealed multiple cavities in the upper lobe of the left lung and numerous cavities in the upper and lower lobes of the right lung; there was an acute necrosis and gangrene of the walls of the cavities in many places, which probably accounted for the sudden death. The cavity which had been drained was almost obliterated, cicatrized and covered with healthy granulations. There were numerous small cavities in close proximity to this which caused the error in the estimate of the size of the cavity at the time of operation. (History furnished by Dr. Clara Ferguson). Bronchiectatic cavities operated, forty-six.

Bronchiectatic Cavities from 1873 to 1897.

Case 1, 1873. Mosler and Huter, Klin. Woch., 1873, p. 43. Male, aged 49 years. Signs of bronchial dilatation of five years' standing. Incision at the upper border of the third rib to 5 cm. from the right border of the sternum; opening of the pulmonary cavity; drainage. Recovery; temporary improvement; death three months later, Oct. 5, 1873. Necropsy: Bronchiectatic cavity of the right upper lobe; amyloid degeneration of the viscera.

Case 2, 1875. Riclus, Klin., Clin. de la Pitie, 1894, p. 39, and Congress de Clinic, 1875, p. 62. Male, aged 50 years. Incision at the level of the third interspace; resection of 6 cm. of third rib. Recovery; amelioration; fistula persistent and accidents of retention; Eslander's operation two months later; death during chloroform anesthesia.

Case 3, 1882. W. Koch, Deutsch Med. Woch., 1882, p. 440. Male, aged 24 years. Signs of cavity in the right lower lobe; four years' duration. Resection of the sixth rib; the pleura adherent; opening with cautery of a large cavity the size of a child's fist situated three finger breadths from the surface of the lung and into which several large bronchi open. Sec-

ond operation, resection of the eighth rib; no large cavity. Third operation, opening of a large cavity between the eighth and ninth ribs. Recovery with marked improvement.

Case 4, 1882. W. Koch, Deutsch Med. Woch., 1882, p. 441. Male, aged 24 years. Signs of cavity in right lower lobe with abundant fetid expectoration, 800 to 1000 c.c. in twenty-four hours; duration, four years. Resection of four inches of fifth rib; incision, oblong, with cautery; opening of cavity the size of a fist; expression of the lung in this cavity and opening of a second cavity the size of a child's head, from which escaped the little fetid fluid. Death seven days later, July 22, 1882; collapse. Necropsy: Phlebitis of the portal vein; amyloid degeneration of the viscera; broncho-pneumonia of the left lower lobe.

Case 5, 1882. Mosler and Huter, Berdl M. A. Cong. for Med., Vol. 2, 1882. p. 87. Pneumotomy without rib resection; opening of a bronchiectatic cavity; drainage. Recovery without fistula; cure maintained fifteen months; death March, 1876; general tuberculosis. Necropsy: Amyloid degeneration of viscera.

Case 6, 1882. Williams, Marshal Lancet, 1882, Vol. 2, p. 1107. Male. aged 40 years. Bilateral pneumonia with right bronchiectasis; abundant fetid expectoration; duration, one year. Vertical incision from fourth to fifth ribs; puncture of the lung with a large trocar; escape of air and fetid pus; drainage. Recovery; moderate improvement; death July 5; cerebral accidents. Necropsy: Total adhesion of right pleural; fistula between fourth and fifth ribs; numerous bronchial dilatations of the anterior portion of the lung, the larger, the size of an orange, has been opened; no other bronchial dilatations; abscess of the right cerebral hemisphere.

Case 7, 1883. Bull, North Med. Archives, 1883, Vol. 15, p. 17. Male, aged 25 years. Chronic general bronchitis with signs of cavity of right base; retraction of the thorax; duration, seven years. Incision in the seventh interspace with cautery; the lung examined with the finger; no cavities of large size; escape of fetid gas; hemorrhage; tamponade, Recovery; amelioration; several exploratory punctures without results; death one month later. Necropsy: Right pleural adhesions; multiple bronchiectases: no large cavity; interstitial pneumonia in the left; pleurisy and bronchial dilatation.

Case 8, 1883. Kazorowski, Deutsch Med. Woch., Vol. 9, No. 29, p. 432. Female, aged 26 years. A bronchial dilatation or purulent pleurisy. Resection of the sixth rib; pneumotomy; opening of a large cavity. Recovery; purulent pleurisy, consecutive.

Case 9, 1883. Laden, Deutsch med. Zeitung, No. 28, 1883. p. 375. Patient expectorates nearly one-half liter of fetid sputa and not containing portions of lung substance; cavity in lower portion of left lung or pleura; general condition bad. Incision without narcosis; large amount of fetid fluid. Recovered; two days later resection of rib; antiseptic irrigation; condition becomes better; improvement slight; fistula remains.

Case 10, 1884, Albert Wiener, Med. Press, July 6, 1884, p. 855. Bronchiectatic cavity in lower left lobe. Opened with thermo-cautery. No result.

Case 11, 1884. Biss and Marshall, Med. Times and Gazette, 1884, Vol, 1, p. 747. Male, aged 32 years. Bronchiectasis of the right base; bacteriologic examination negative; duration six months. Operation between the tenth and eleventh ribs; a puncture of the pleura; escape of air and bloody fetid liquid; drainage; irrigation with permanganate not tolerated. Death eighteen days later; cerebral accidents. Necropsy: Multiple bronchiectasis of the right base, of which the larger have been opened; the left lung normal; two brain abscesses.

Case 12, 1884. Tausustein, Cent. f. Chir., 1884, p. 290. Male, aged 37 years. Fetid, abundant expectoration; duration several years. Resection of four inches of the anterior portion of the eleventh rib; puncture of the lung with a trocar; dilatation of the tract; large cavity with resistent walls; insertion of drain. Recovery. According to Quincke this patient met death from hemoptysis.

Case 13, 1885. De Cerenville, Rome Med. Suisse Romande, 1385, Vol. 5, p. 462, obs. 1. Male, aged 50 years. Sacciform excavation of right lower lobe; puncture with a large trocar. Recovery. Death two months later; mania; refused nourishment. Necropsy: Pleural adhesions; a regular cavity surrounded by sclerotic tissues; no tuberculosis.

Case 14, 1885. De Cerenville, Ibid., obs. 2. Cavity of the left base; duration, four years. Puncture with a large trocar; dilatation. Recovery. Death nine weeks later. Necropsy: Irregular excavation of the left lower lobe; kidneys and liver sclerotic.

Case 15, 1886. Rochelt, Wiener Med. Presse, 1886, p. 1264. Male, aged 54

years. Bronchiectasis of the right lower lobe; examination for bacilli negative; duration three years. Operation in two sittings; first is resection of sixth rib; second is pneumotomy forty-eight hours later with the cautery; cavity the size of a hen's egg; drainage. Recovery.

Case 16, 1886. Rochelt, Weiner Med. Presse, No. 37. Female, aged 36 years. Fetid expectoration; fever; abscess formation at the base of left lung with excavation in the sixth interspace; incision for empyema. No amelioration of general symptoms; incision made in lung; pus and blood escaped; patient had an attack of hemoptysis; iodoform gauze tampons inserted; wound washed out next day; débris was taken out; iodoform tampons. Fever abated; cough and fetid expectoration ceased; complete recovery of gangrenous excavation inside of four weeks.

Case 17, 1886. Williams and Godley, Brit. Med. Jour., 1886, Vol. 1, p. 590. Male, aged 67 years. Bronchiectasis of the left base; duration two years. Incision at the level of the eighth interspace. Recovery. Death from cardiac syncope one year after operation.

Case 18, 1886. Williams and Godley, Med. Chir. Transactions, 1886, Vol. 69, p. 234. Female, aged 21 years. Multiple bronchiectasis at the level of the sixth and seventh interspace. Resection of an inch of the seventh and eighth ribs; puncture of the lung; drainage. Recovery; amelioration.

Case 19, 1887. Benson and Godley, Lancet, 1887, Vol. 1, p. 716. Male, aged 55 years. Signs of cavity upon the left in the axillary line. Incision in the tenth interspace. Death three days later. Necropsy: Multiple dilatations of the whole left lower lobe; no large cavity; fatty degeneration of the heart; nutmeg liver.

Case 20, 1887. Godley and Powell, Lancet, 1887, Vol. 1, p. 716. Male, aged 35 years. Duration of symptoms one year. Death from chloroform syncope at beginning of operation. Necropsy: Bilateral general bronchial dilatation.

Case 21, 1887. Godley, Lancet, 1887, Vol. 1. p. 717. Female, aged 29 years. Bronchiectasis limited to the left base. Resection of the tenth rib; opening of a bronchial cavity; drainage. Recovery. Not seen after leaving hospital.

Case 22, 1887. Stewart, Brit. Med. Jour., 1887, p. 179. and 1893, Vol, 1, p. 1147. Male, aged 27. Signs of cavity at angle of left scapula; duration nine years. Incision; rib resection; opening of a pulmonary cavity; counter-opening and drainage. Recovery.

Case 23, 1888. Hoffmokl, Soc. Imp. Roy. des Med. de Vienne, January, 1888. Male, aged 32 years. Rib resection; incision of the lung with cautery; opening of a cavity located at the depth of 7 cm.; escape of air. Recovery.

Case 24, 1889. Mackey, Brit. Med. Jour., 1889, Vol. 2, p. 660. Male, aged 20 years. Signs of cavity of right base; duration four years. Intercostal incision, pleuro-pulmonary adhesions; puncture; operation suspended on account of cough; eight days later incision of the lung; opening of a cavity filled with pus, Recovery. Death six weeks later. Necropsy: Multiple cavities occupying the whole of the right lower lobe; focus of pulmonary gangrene in the left lower lobe, but no bronchial dilatation of this side:

Case 25, 1889. Mosler and Volk, in Hortwin Inaug. Dissert., Griefsweld, 1889. Male, aged 13 years. Bronchiectasis of the left lobe. Resection of the third rib; opening of a cavity the size of an apple; counter-opening between the ninth and tenth ribs at the level of which we came upon a cavity containing one and one-half liters of pus; pleural adhesions. Death seven days later.

Case 26, 1890. Osler, Johns Hopkins Bulletin, Vol. 1, 1890. Male, aged 60 years. Had pneumonia several times in many years; has had pain in side and chest, spitting blood at times; cough and fetid expectoration; clubbed fingers; wasted; left side of chest retracted; amphora sounds; temperature 98 to 101. Resection of portion of fourth and fifth ribs; a series of cavities opened; these were packed with iodotorm gauze. Patient sank after operation and died on third day. Necropsy: General bronchiectasis; no tuberculosis.

Case 27, 1891. Krecke, Munich Med. Woch., 1891, p. 399. Male, aged 48 years. Bronchial dilatation of the left base; duration several years. Exploratory punctures; escape of pus; rib resection; incision; no pleural adhesions; pneumothorax makes the examination of the lung impossible. Death several hours later. Necropsy: Multiple bronchiectatic cavities; large cavity in the left lower lobe.

Case 28, 1891. Itaache, Mag. forgker, 1891, No. 4, in Quincke Mittheil aus d. Greuz. gebdaul-wehir, 1895, Vol. 1, p. 44, obs. 7. Male, aged 17 years. Sacciform bronchiectasis; signs of cavity; duration six years. Explora-

tory puncture; resection of 5 cm. of the eighth rib in the axillary line; no pleural adhesions; suture of the lung to the lips of the wound; eight days later opening of a cavity with cautery. The immediate result was amelioration. Peristence of a fistula; expectoration reduced from 900 to 100 c.c.; Death nine months later from meningitis (abscess of the brain).

Case 29, 1892. S. Coupland, Lancet, 1892, Vol. 2, p. 869. Female, aged 16 years. Cavities of the left base; no bacilli; duration two years. Operation by Pence-Gould; two exploratory punctures, below and above the eighth rib, May 10; May 17, diffuse swelling at level of puncture; incision; opening of pulmonary cavity; resection of eighth rib. Death from chloroform syncope. Necropsy: Saccular dilatations of the bronchi in the left lower lobe; another bronchial dilatation of the left upper lobe and the right lung.

Case 30, 1893. Hoffmokl, Wiener Med. Presse, 1893, April 30. Male, aged 43 years. Sign of cavity in right apex. Incision with cautery in the second interspace; escape of pus; drainage. Recovery.

Case 31, 1895. Reclus, Klin. Clin. de la ditie., 1894, p. 39, Cong. de Clin., 1895, p. 62. Male, aged 50 years. Incision at the level of the third interspace; resection of 6 cm. of third rib. Recovery. Amelioration; fistula persistent and accidents of retention; Eslander's operation two months later; death during chloroform anesthesia.

Case 32, 1895. Biondi, Clinica Chir.-Milaro, 1895, Vol. 3, p. 475. Male, 26 years. Left interstitial pneumonia, putrid brochiectasis; dry adhesive pleurisy and the existence of a superficial cavity in the lower part of the scapular region. Pneumectomy performed. Death fifteen hours later. Necropsy: Postmortem purulent pleurisy from escape of bronchiectatic fluid into pleuric cavity during the operation; multiple bronchi dilatations.

Case 33, 1895. Abrona, loc. cit., ibid. Bronchiectasis; fever and abundant expectoration. Pneumectomy performed. Recovery; temporary amelioration; reappearance of the irregular fever and expectoration several days after the operation.

Case 34, 1895. Quincke, Mitt. aus ten Granzg. der Med. Chir., band 1, H. T. 1, 1895, p. 15, obs. 2. Male, aged 25 years. Multiple bronchiectasis; signs of cavity upon the left posteriorly and at the base; expectoration amounted to 150 to 200 c.c.; duration two months. Incision in eighth interspace; three applications of paste of chlorid of zinc; eighteen days later resection of the ninth, tenth and eleventh ribs; application of the past of chlorid of zinc four days later; exploratory puncture; pus; incisione with cautery. Recovery; Patient left in August, 1896, and returned to his work.

Case 35, 1885. Quincks, loc. cit., p. 41, obs. 12. Male, aged 49 years. Cylindrical bronchiectasis of left base. Application of paste of ZnCl. 2; four weeks later resection of 4 cm. of tenth rib; no cavity; opening of a bronchiectasis. Recovery; amelioration; left hospital five months later.

Case 36, 1895. Quincke, loc. cit., p. 17, obs. 3. Male, aged 34 years. Multiple bronchiectasis of left base; retraction of thorax; no signs of cavity; duration several years. Incision in eighth and ninth interspace; application of zinc chlorid; resection of ninth and tenth ribs; wall incised with cautery; Zn. Cl. 2 on lung. Recovery; amelioration; patient escaped tuberculosis.

Case 37, 1895. Quincke, loc. cit., p. 18, obs. 4. Male aged 36 years. Brochiectasis of left base, secondary to a chronic bronchitis; twelve years' duration. Resection of ninth rib; Zn. Cl. 2 applied without result; later resection of the tenth rib. Recovery; amelioration; death two years later.

Case 38, 1895. Quincke, loc. cit., p. 27, obs. 7. Male, aged 66 years. Bilateral multiple bronchiectasis with sacciform dilatation in left base; signs of cavity; duration four years. Resection of 7 cm. of ninth rib; exploratory puncture without result; no pleural adhesions. Death; collapse before the incision of the cavity. Necropsy: Amyloid degeneration of viscera.

Case 39, 1895. Quincke, loc. cit., p. 34, obs. 9. Male, aged 12 years. Multiple cylindrical bronchiectasis of whole right lung; no signs of cavity; duration three and one half years. Resection of second, third, eighth and ninth ribs; exploratory puncture. Recovery; no amelioration.

Case 40, 1895. Quincke, loc. cit., p. 32, obs. 8. Female, aged 42 years. Bronchiectasis of left base; sacciform and cylindrical; no signs of cavity; five applications of Zn. Cl. 2. Resection of tenth rib; incision with cautery. Death four days later; collapse. Necropsy: Small bronchial dilatations; large cavity in left apex.

Case 41, 1895. Quincke, loc. cit., p. 35, obs. 11. Male, aged 31 years.

Sacciform bronchiectasis of left base; no signs of cavity or pneumonia; duration five years. Incision; application of Zn. Cl. 2; resection of 4 cm. of tenth rib; incision of the cavity; drainage. Recovery; fistula. Death during second operation; hemorrhage and entrance of air into pulmonary veins.

Case 42, 1895. Quincke, loc. cit., p. 37, obs. 11. Male, aged 54 years. Sacciform bronchiectasis of left base. Three applications of Zn. Cl. 2 paste; resection of eighth, ninth and tenth ribs; pleural adhesions. Death one month later from hemorrhage.

Case 43, 1895. Walter, Congress de Chir., 1895, p. 101. Female, aged 26 years. Chronic bronchitis with bronchial dilatation of entire left lung; purulent pleurisy existed in lower portion of left pleura, probably consecutive to a point of pulmonary gangrene, with pleuro-bronchial fistula. Resection of seventh and eighth ribs posteriorly; pleural adhesions very large; resection of eighth and ninth ribs; opening of an enormous cavity; tamponade with gauze and sponges. Recovery without fistula after secondary throrocoplasty.

Case 44, 1896. Pierro, Selbet in de Agincourt thesis de Paris, 1896, p. 73, Male, aged 45 years. Bronchiectasis of left base; expectoration reaching as high as one and one-half liters. Resection of 5 cm. of the seventh rib; opening of a large cavity the size of a nut, surrounded by other small cavities at a depth of 5 to 6 cm.; escape of fetid pus; drainage. Recovery; marked improvement. Death twenty months later.

Case 45. Gerard Marchant in Guillmont and Herbert, Soc. Anatomy, 1896, p, 952. Bronchiectasis of right base. Resection of seven to eight cm. of fourth rib; resection of third rib; cavity located higher than had been supposed; opening of a cavity the size of a hen's egg; walls of cavity bleeding; two forceps left attached. Amelioration. Death four months after the operation. Necropsy: Right lung, except at a point in the upper lobe, is entirely destroyed and perforated by irregular cavities, the larger of which are the size of a walnut.

Case 46, 1896. Wills, Lancet, 1896, Vol. 1, p. 1563. Unilateral bronchiectasis. Rib resection; several punctures; negative; pleural adhesions. Death on the eleventh day. Necropsy: Unilateral cylindrical bronchiectasis without a large cavity.

Case 47, 1897. Coppehkow, Wratch. 1897, No. 6. Female. Bronchiectasis with hemoptysis. Pneumotomy; opening pocket the size of a nut. Recovery of hemoptysis; several days later second pneumotomy; opening of several cavities. Cure maintained several months.

Case 48, 1897. Nelaton in the Busard, Paris, 1897. Male, aged 34 years. Repeated bronchitis during past four years and secondary bronchiectasis of left base; interlobar pleurisy. Incision in the sixth interspace; no resection of ribs; opening of a cavity; drainage; irrigation incites cough. Death twelve days later; coma. Necropsy: Multiple dilatations of bronchi of left lower lobe; large cerebral abscess occupying the frontal and cerebral lobes; but one bronchiectatic cavity opened.

Case 49, 1897. Nelaton in the Brusard, Paris, 1897. Female. Brochiectasis. Pneumotomy performed. Recovery; amelioration for six months; recurrence.

Gangrene of the Lung.—Gangrene of the lung may be diffuse or circumscribed. It has four distinct stages: Necrosis, putrefaction, demarcation and elimination, and reparation. It is most frequently a result of acute pneumonitis. Andral found it present in 3.3 per cent of post mortems for pneumonia; Hughes found it in over 10 per cent. in Guy's Hospital (Paget). In place of resolution taking place at the proper time there is a death of lung tissue. The lung tissue is unable to react from the destructive effect of the infection by reason either of its character or intensity, and as a consequence gangrene results. Gangrene may be the result of a foreign

body in the bronchus, an inhalation infection, a septic embolus, necrosis of an infarct, etc. It may be the result of an extension of infection from a bronchiectatic or abscess cavity or from a putrid bronchitis, when it is often multiple, as shown in a case by Walter D. de Jersey.[57] It may result from perforation into the lung of abscess cavities, as mediastinal or subphrenic, from perforation of the esophagus, with foreign bodies, as in a case reported by Pasteur, London, and operated by Bilton Pollard, in which a communication was found between the esophagus and the bronchus at its bifurcation; a gangrene of the right lung was produced; it was treated by double drainage. Gangrene occurs most frequently in the lower lobe, and is most often situated near the surface of the lung, next near the center and less frequently near the interlobar septum. (Tuffier.) After necrosis it may undergo rapid decomposition, depending upon the presence of saprophytes. In the diffuse variety an entire lobe may be involved. (Trier.) The separation of the slough is slow; the sequestrum may be expelled through the bronchus or through the chest wall by extension of the necrotic processes. The gangrenous areas are multiple in 15 per cent. of the cases.

Diagnosis.—The symptoms of gangrene of the lung are usually very pronounced, though they may merge from those of a severe pneumonia. When the typhoid mutterings, nervous prostration and evidence of intense intoxication continue beyond the usual limit for a pneumonia, gangrene should always be suspected. If it be diffuse, the breath and expectoration soon become offensive; the latter is a brown, frothy, muco-purulent fluid; it is often profuse; the amount expectorated in one seizure of coughing is some index to the size of the cavity; there is probably no odor so offensive as that of the breath in gangrene of the lung. In the circumscribed variety the gangrenous cavity may not communicate with the bronchus, in which case there would be no odor. There is usually circumscribed dullness but rarely edema of the chest wall. Exploratory puncture gives

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57 Lancet, London, Jan. 21, 1892, p. 27.

a foul-smelling fluid or a very offensive gas. This procedure is not devoid of danger. Gangrene of the tract of the needle and gangrene of the wall of the chest with emphysema followed in case of E. Bull; incision and drainage were resorted to with recovery. Errors in localization of cavities have been of frequent occurrence with the best diagnosticians. Barry called attention to this in 1726. Tuffier found exploratory puncture positive in but two-thirds of the cases. He emphasized its dangers and said it should be restricted to the time of operation. Lejous[58] removed the eighth, ninth and tenth ribs and detached pleura, made digital inter-pulmonary exploration for a case of gangrene, presumably of the lower lobe with negative result; the patient succumbed, and post mortem showed the gangrene in the upper lobe. In another case in which he made inter-pulmonary palpation he succeeded in locating the induration and opened a cavity near the spine. He favors this method. Dr. Routier,[59] Paris, favors digital palpation, and located in this manner an inter-lobar abscess ten centimeters from the surface of the lung.

The following diseases, bronchiectasis, fetid bronchitis and gangrenous pleurisy may be confounded with gangrene. The history aids very much in the differential diagnosis, while the physical signs and the result of exploratory puncture may be the same in both cases. Under medical treatment the mortality of this disease is upward of 80 per cent. Surgery has reduced this mortality somewhat, although it is still great. Sonnenberg says that in seventy-four operations 35 per cent. recovered. Langenbeck operated succesfully as early as 1879. (Gluck.) The surgical treatment of gangrene received its greatest impetus from Bull, Copenhagen, who made incision and drainage a recognized surgical procedure; his suggestions and conclusions have scarcely been improved upon. I therefore quote the following: "Limited pulmonary gangrene recovers without operation or puncture; extensive gangrene cannot be cured by bronchial drainage or aspiration, as the necrotic portions cannot

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58 Paris Med. Week, February, 1897, p. 91.
59 Paris Med. Week, Feb. 26, 1897, p. 97.

get out; free incision should be made when gangrene is diagnosticated. If cavities are multiple, more than one opening may be necessary; operation is the only therapeutic efficient; pleuritic adhesions are an essential condition; vibration of needle with puncture is not a reliable negative symptom, nor absence of vibration positive of existing adhesions." Thomas Williams in 1877 diagnosed pneumonia followed by abscess and operated; patient died of pneumonia. When this was reported, Thompson, Bryant and Mamder favored this operation in discussion; Douglas Powell opposed it. Lowson reported a fatal case. Berkely Hill Sedgwich and S. C. Smith reported recoveries; the latter gave as indications for operation: 1, in cases where the gangrenous cavity is imperfectly drained through the bronchus; 2, where too much irritation is produced from the discharge; 3, in rapid emaciation; 4, unquestionable signs of cavity present.

The consideration of the results obtained in operations for gangrene shows a marked improvement as time has advanced, from Truc's cases, 1879 to 1884, 13 operations, 3 cures, 2 relieved and 2 on the way to recovery, 6 deaths. To those of Reclus, 1885 to 1895, 14 operations, 11 cured, 1 improved and 2 deaths.

Chloroform is the best anesthetic. (Tuffier.) The Schleich method of local anesthesia is good, and I consider it indicated here more than anywhere else. The question has been raised, should the operation be performed immediately or should we wait for certain pathologic changes to take place? The rules advanced in favor of delay are: 1, we should not operate until liquefaction of the slough has taken place; 2, we must be sure adhesions are present; 3, we must remember that circumscribed cases recover of themselves. The latter is the only rule of significance; when the abscess is small and there is free expectoration with the absence of toxic symptoms, time may be given with the hope of recovery without operation, though the sequestrum is rarely ejected through a bronchus. It must not be expected in the early stage that a cavity will be found; at this stage it will be a succulent, boggy mass, with very offensive odor; the mass should be freely incised for drainage, but no

effort should be made at excision. The gangrenous cavity may have large vessels traversing it in which thrombosis has not taken place. Runneberg,[60] Fenger and Hollister[61] were early and strong advocates of the free incision and ample drainage.

It is not necessary to wait for the separation of the slough before operating, as the danger of retention and the extension of the process increases as time advances; there is little danger of operating too soon, as the process is usually advanced before the diagnosis is made; neither is it necessary to wait for adhesions. The pleural cavity is most always infected and should be freely drained; recoveries in the absence of adhesions are reported by Krause, Paget, Reclus and others. When the gangrene is situated high up it is very desirable to have adhesions, and unless they exist at the time of operation they should be induced by exposure and tampon or suture after the method of Péan, Roux and Godlee. The latter reports a case in which he adopted this method.[62] It is desirable to open into the most dependent portion of the cavity, as it allows of better drainage and prevents the escape of pus into the bronchus, though it contributes little to the healing, as this is accomplished by cicatricial contraction. If the gangrene be in the depth of the lung, the pulmonary tissues should be freely incised, hemostasis secured and the surface protected by the application of the Paquelin cautery. The trocar and canula are not to be used in gangrenous cases, as they do not admit of sufficient drainage and are likely to be occluded by the slough. Injections of disinfecting material have proven a failure and should not be used. O. Hewdke, of Warsaw, used various injections in four cases without a cure.[63] If the operation be performed early the question arises, Shall the necrotic portion be excised, or merely incised and drained? The principles of surgery governing this appear to be the same as those governing gangrenous tissue in other portions of the body, *i. e.*, the sphacelus

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60 J. W. Runeberg, Helsingfors, Deut. Arch. f. Klin. Med., 1887, xli.
61 Am. Jour. Med. Sc., Philadelphia, 1881, Vol. xxxii, p. 370.
62 Lancet, London. Oct. 20, 1888, p. 768.
63 Lancet, London, Feb. 20, 1892, p. 440.

should not be excised; it will separate at the line of demarcation. The auto-separation appears to have an additional advantage, as it insures the thrombosis of the vessels and lessens the liability to hemorrhage in a location in which the surgeon is not entirely master of the situation. When the sphacelus is detached, it should be carefully removed at the time of operation. The cavity should not be irrigated, particularly if it communicate with a bronchus; large incision and free drainage is all that is necessary. The period of time which is required for the separation of the slough is indefinite. I have found in my experiments that pressure necrosis of the lung with separation of the stump after ligature takes place very slowly; it requires ten to twelve days, which would indicate that the line of demarcation forms slowly. The length of time required for the closure of the cavity depends upon its size. It may, however, close rapidly, as is shown by the following case:

Mr. F. W. M., age 58, was seen by me in a consultation, out of the city, Nov. 16, 1893. He was in the third day of an ordinary croupous pneumonia of the lower lobe of the right lung. I saw him again on the 24th, eight days later. Resolution was well established, the temperature had subsided to 99 degrees morning and 100.4 degrees evening. I learned later from his physician that his convalescence from the pneumonia was slow; two weeks after my last visit, Dec. 7, I was informed that he had a thrombo-phlebitis of the left leg and that he still had a slight cough, with no expectoration. His temperature with the phlebitis reached 102.3 degrees. His convalescence from the phlebitis was also slow. On the 29th of December he complained again of pain in the right side (not severe), began to cough and had a slight muco-purulent expectoration. I saw him in consultation on Jan. 6, 1894, seven weeks after the onset of his pneumonia. He was having night sweats, had a dry hacking cough and slight dyspnea. There was still some edema and tenderness in the leg and thigh. An examination of the right lung revealed a circumscribed area of dulness two inches in diameter, beginning just below the angle of the scapula. This area was sensitive on deep pressure; there was no edema of the wall. Respiratory sounds were absent and vocal fremitus diminished. The exploratory puncture gave one-half drachm of brown, sanguino-purulent, particularly offensive fluid.

Diagnosis. — Circumscribed gangrene not communicating with the bronchus. The question arose, was the phlebitis a sequence of the pneumonia and the gangrene the result of a septic embolus from the vein, or was the gangrene the direct result of the pneumonia and the phlebitis one of the manifes-

tations of sepsis? This is a question which I am unable to answer with any degree of certainty, but from the course of the disease I believe it was the result of a septic embolism.

Operation.—St. Joseph's Hospital, Chicago, January 9, an incision 2½ inches long was made in eighth interspace immediately below the angle of the scapula. As the pleura was approximated the tissues were edemetous, showing that adhesions existed. (This tissue edema is one of the best evidences of adhesion of a suppurating focus to the wall either in the abdomen or chest; it far exceeds in value the vibration of the needle.) The pleura and underlying tissues were divided so as to admit the index finger; there was an escape of two ounces of fetid pus and some gas. Digital examination revealed a slough which was extracted with forceps; the cavity could be readily examined with the finger; its wall was irregular; there was no hemorrhage; it was not irrigated; a rubber drain was inserted; five days after the operation the odor had entirely disappeared and there was a clear serous discharge. On the twelfth day the drain was removed and on the thirty third day he left the hospital with the wound entirely closed. This illustrates how early the drainage may be removed and how rapid the convalescence. Within three months he gained forty pounds and enjoys excellent health at the present time.

The extremity to which these patients may be reduced before an operation, and still be able to recover, is remarkable, as may be seen from the history of many cases; the surgeon should feel it his duty to operate on them even when it appears that they would not survive the hour of operation. The following is a good example:

Thos. K., age 22, on Sept. 9, 1897, was seized with a chill, severe pain in the left side and the usual symptoms of pneumonia. On the twelfth day of the pneumonia his temperature dropped and his symptoms improved. Four days later he began to cough and there was an expectoration of an offensive bloody fluid. A few days after the expectoration became yellow and still more offensive. The quantity increased with great rapidity, so that at the end of ten days the patient was expectorating a pint or more daily. He emaciated rapidly and became very weak. This deplorable condition continued until the 29th of December, when he was sent from the hospital to his home to die. Two weeks later he was seen by a very able practitioner who said he could not possibly survive three days. On the 2d of March I saw him in consultation; his pulse was 156, respiration 44, temperature 97 degrees; he was coughing incessantly; he could not speak above a whisper; the odor in the room from breath and expectoration was nauseating; he was emaciated to a skeleton, resting in a semi-stting position from which he could not be moved; his pupils were dilated and he was apparently drowning from the accumulation of

fluid. The nurse stated that this had been his condition for nine weeks. From this history obtained from the patient's friends and nurse, and the physical signs present, a diagnosis of gangrene of the left lung was made. Local anesthesia was employed and a three inch incision was made in the eighth intercostal space, post-axillary line; about a quart of most offensive pus with necrotic shreds of lung escaped; a double drainage tube was inserted; he gave a few gasping respirations and I thought he was dying; the cough subsided in a few moments, his breathing became easier, and when I heard from him last, three weeks later, he was able to sit up in bed. The long period of time which had elapsed between the apparent hopelessness of his condition and the time of the operation is an illustration of how long these patients stand the deleterious effects of the pus accumulation and how they rally when relieved.

The complications that arise in operation for gangrene are pneumothorax and hemorrhage. In the former the lung should be harpooned or grasped by the forceps and sutured to the edge of the wound. Tuffier collected nine cases of hemorrhage with four deaths. The hemorrhage usually followed the removal of the tampon; the quantity of blood necessary to cause death under these conditions is very small compared with the fatal quantity from external hemorrhage. The greatest care should be exercised in the dressings, and irrigation should be avoided. Priestley Leech[64] of Halifax introduced iodoform into the cavity through the drainage tube with good effect. Tier,[65] Copenhagen, in four cases operated had three fatalities; one death from hemorrhage from drain pressure; in the successful case one-half of the lung was gangrenous, still patient recovered. Seitz[66] collected nineteen cases of gangrene operated, with four recoveries, four improvements and eleven deaths. Perier[67] reports continuous pleuro-pneumonic suture and drainage in second interspace for gangrene; the suture was made after opening the lung; recovery

I have collected 96 cases of gangrene of the lung operated upon: 53 completely recovered; 3 recoved with fistula; 3 termination unknown; 37 died. 1 from cerebral embolism, 1 from meningo-encephalitis, 1 from pneumonia, 17 from undetermined causes, 3

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64 Lancet, Jan., 1894, p. 87.
65 Cong. Inter. Med., Copenhagen, 1884, Vol. vii, p. 146.
66 Wurtzberg, Aschaffenberg, 1888, Schippner, W. & C.
67 Lancet, London, 1892, p. 777.

from diffuse gangrene, 2 from septicemia, 4 from pyemia, 4 from exhaustion, 4 from hemoptysis.

Gangrene, from 1879 to 1897: Years According to Rotation.

Case 1, 1879. Cagley and Lawson, Brit. M. J., 1879, Vol. 1, p. 550. Male, 40 years. Gangrene, general condition grave; five weeks duration; pneumonia of left base posteriorly. Signs of cavity; adhesions. Exploratory puncture positive. Incision in ninth interspace, 5 oz. fetid pus, drainage. Death six days later. Necropsy: complete pleural adhesions, cavity with irregular walls, granular kidney, tuberculosis of right apex.

Case 2, 1880. Salomon Smith, Lancet, 1880, Vol. 2, p. 86. Male, 60 years. Gangrene. Duration, two months. Acute pneumonia, spurious, right base posteriorly. Signs of cavity. Exploratory puncture, putrid gas. Pneumotomy at the level of lower angle of scapula, no rib resection, ligation excited coughing. Death eight days later.

Case 3, 1881. Bull. Nordiskt. Archiv., 1881, vol. 13, p. 27, No. 17, in Runeberg Deutsche Archiv. für Klin. Med., 1887, p. 91. Female, 23 years. Gangrene. Duration two months. Acute broncho-pneumonia, left apex anteriorly. Signs of cavity. Puncture with a Pravaz syringe shows serosanguinous flood. Incision two inches long in fourth interspace at level of the puncture, dilatation with forceps; some days later extraction of fragments of friable lung; carbolic irrigation. Recovery, several attacks of hemoptyses during following weeks.

Case 4, 1882. Leyden and Koch, 1882, quoted in Fabrickaut. Male, 24 years. Gangrenous cavity in right lung, lower part; putrid bronchitis. Resection of sixth rib with thermo-cautery, drainage. Improvement.

Case 5, 1882. Leyden and Koch, 1882, quoted in Fabrickaut. Female, 29 years. Gangrenous cavity in right lung. Opened by thermo-cautery, washed out with thymol sol., drainage. Died from septicemia. Necropsy: suppuration near portal vein, broncho-pneumonia of opposite side.

Case 6, 1883. Boccheni, Cent. für Chir., 1883, No. 37, p. 598, and Med. and Raccoglitore, 1891, Vol. 2, p. 561, 5th series. Female, 27 years. Gangreous abscess of lung; pneumonia; right apex laterally; adhesions, Exploratory puncture positive. Incision in right interspace without rib resection; puncture, then pneumotomy; issue of pus and of pulmonary débris. Amelioration; case reported before complete recovery.

Case 7, 1883. Sutton in Mosler, Wiesbaden, 1883, p. 38, and in Ramsay, Obs. 2. Male, 34 years. Gangrene, large cavity; Pneumonia five years previously; left base. Signs of cavity. Exploratory puncture, issue of pus. Incision in sixth interspace, drainage daily, carbolic irrigation. Sudden death thirty-first day. Necropsy: large cavity of the base.

Case 8, 1884. Cagley and Gould, Brit. Med. Jour., Jan. 1884, Vol. 1, p. 1045. Female 12 years. Acute metastatic gangrene. Duration eight days. Pyemia following otitis with an old mastoiditis; left base posteriorly. Signs of cavity. Puncture with large trocar, issue of pus and débris. Recovery in forty days.

Case 9, 1884. Drinkwater, Trans. of the Northumberland and Durham Society, May 15, 1884, in Revue des Sc. Méd., 1885, Vol. 25, p. 300. Male, 60 years. Acute gangrene. One month duration. Chronic bronchitis, acute pneumonia; right apex; adhesions. Incision of an abscess just below the clavicle, drainage of a pulmonary cavity through intercostal space. Improvement, recurrence three month later, incision and resection of one and one-half inches of the third rib, ablation of a portion of the gangrenous lung, drainage and irrigation; recovery without fistula.

Case 10, 1884. Fenger, Med. News, June 7, 1884, in Cent. f. Chirurg. 95, p. 208. Male, 36 years. Circumscribed gangrene. Six weeks duration. Croupous pneumonia; right base anteriorly. Signs of cavity. Puncture with hypodermic issue of gangrenous fluid. Resection of the fifth rib, puncture of the cavity and incision with the cautery, salicylic irrigation gave rise to cough, drainage. Rapid improvement, drain removed on twenty-second day; fistula six weeks after operation; recovery.

Case 11, 1884. Fermey, Dublin Jour. of Med. Sciences, Jan. 19, 1884, in Revue des Sc., 1885, Vol. 25, p. 299. Male, 30 years. Gangrenous cavity and empyema; base posteriorly. Incision at the level of lower angle of the scapula. Death five days later. Necropsy: diffuse gangrene.

Case 12, 1885. Gairchier and McLeod, quoted by Fabrickaut, 1885. Boy. Gangrenous cavity; left lung. Resection of ribs, drainage. Death after few days.

Case 13, 1886. Brookhouse, Lancet, 1886, Vol. 1, p. 1111. Male, 36 years. Gangrenous abscess, three months duration. Spurious pneumonia; left

base posteriorly. Signs of cavity; adhesions. Puncture with large trocar in eighth interspace, axillary line, daily irrigation, cough. Death seven days later.

Case 14, 1886. Hevilich, Charité Annal, 1886, Vol. 2, p. 230. Female, 27 years. Pulmonary abscess, expectoration purulent and fetid. Three weeks duration. Puerperal infection; right base posteriorly. Signs of cavity; adhesions. Puncture positive, several punctures at the level of lower border of ninth rib, without result; positive puncture in ninth interspace in axillary line. Resection of four cm. of ninth rib; puncture, 3 c.c. of pus and fetid clots, dilatation of the tract, we come upon the cavity the size of a fist with irregular walls. Hemorrhage into cavity during operation arrested by tamponade; death three days later. Necropsy: Puerperal metro-peritonitis and para-metritis, right pneumonia and cavity of base of right lung the size of goose egg, embolism of the pulmonary artery, firm adhesions, another focus of pulmonary necrosis superficially in the right face.

Case 15, 1886. Perigmbec and de Beurnism, Francais Médicale, 1886. Vol. 2, p. 1463. Female, 12 years. Gangrene, hemoptysis and cavity, and bacilli. Several years duration. The pulmonary affection not determined; right antero-lateral region. Resection of 5 cm. of fifth and sixth ribs, pneumotomy with the cautery at depth of 3 cm., drainage, no irrigation. Complete recovery, no details.

Case 16, 1886. Wagner, Berlin Clin. Woch, Sept. 6, 1886. Male, 17 years. Gangrene of the lung and putrid pleurisy; croupous pneumonia of left side. Incision in eighth space near vertebral column, offensive odor, piece of gangrenous lung discharged through wound. Gradual recovery.

Case 17, 1887. Zezas, Corresp. Blatt of Schweiger, Aerzte, 1887, Vol. 17, p. 455. Male, Pyemic abscess. Five and one-half months duration. Pyemia secondary to a foreign body in the larynx; right base posteriorly. Signs of cavity; insufficient adhesions. Incision and resection of seventh rib (6 cm.), opening of cavity at a depth of 3 cm., tamponade and drainage. Death fourteen days later. Necropsy: Pyo-pneumothorax, insufficient adhesions, central edema from thrombosis of the jugulars, abscesses in the two lungs.

Case 18, 1887. Runeberg, Deutsche Aschit. für Med., 1887, Vol. 41, p. 91, Obs. 2. Female, 23 years. Gangrene and circumscribed pneumothorax; chronic bronchitis and multiple bronchiectasis bilateral; left upper lobe anteriorly and posteriorly. Signs of cavity; total adhesions. Exploratory puncture without result, puncture in the axillary line to the fourth interspace positive. Resection of 4 cm. of fourth rib in post-axillary line, small cavities, no pus, punctures with a fine trocar, no cavity. Two days later issue of pus through the tract; death ten days later. Necropsy: communication of the pelvis with the wound, gangrenous cavity, of lower lobe; cavity of the upper lobe of 4 cm. into which a bronchus opens, numerous small cavities in the upper and lower lobes, no more in the left lung, small cavities in the right at the base.

Case 19, 1887. Leyden, Arch. Gen. de Méd., 1887, Series 7, Vol. 20, p. 472. Gangrene; puncture. Incision, escape of large quantity of pus, irrigation. Recovery.

Case 20, 1887. Guermonpuz, Académie de Médicine, 1887, Vol. 18, p. 332. Male, 23 years. Gangrene. Four years duration. Typhoid fever; base. Signs of cavity. Exploratory pleurotomy; resection of two ribs, two pneumotomies. Recovery.

Case 21, 1887. Godlee, Lancet, 1887, Vol. 1, p. 512. Female, 19 years. Gangrenous abscess. Fourteen days duration. Pneumonia of six weeks duration; left base. No signs of cavity; adhesions; exploratory puncture. Incision in the eighth interspace without rib resection, cavity at a depth of 6 cm., drainage. Recovery, three and a half months later slight scoliosis.

Case 22, 1887. Godlee, Lancet, 1887, Vol. 1, p. 513. Female, 44 years. Gangrenous abscess; eight days duration. Pleuro-pneumonia of twenty-four days duration; right base anteriorly. No signs of cavity; adhesions. Incision in the seventh interspace above the nipple, no rib resection, drainage. Recovery, six weeks after opening of an abscess into the colon (Quincke) necessitated between a gangrene or an empyema.

Case 23, 1887. Dubmeil, Gaz. Hebd. des Sc. Méd. de Montpellier, 1887, p. 517. Female, 25 years. Chronic gangrene; duration fourteen months. Broncho-pneumonia, hemoptyses, no tubercle bacilli; right base posteriorly. Signs of cavity; adhesions. Puncture with fine trocar for the diagnosis of adhesions. Incision, resection of one and one-half cm. of the sixth rib; pneumotomy; opening of a series of cavities of the size of a

hazel nut, drainage, boric acid irrigations incite cough and suffocation. Death one month later without improvement.

Case 24, 1888. Koch, in Openchowski Wratsch., 1888, p. 743, in Zeit. für Klin. Med., 1889, Vol. 16, p. 393. Male, 30 years. Gangrenous abscess; four months duration; pneumonia four months previously; right base between the post-axillary and mammary lines. Signs of cavity; adhesions. Two exploratory punctures negative, one month and three weeks before the pneumotomy. Resection of fifth and sixth ribs (10 cm.), opening of a cavity at a depth of 2 or 3 cm. the size of a fist, gangrenous focus in an old abscess, cauterization with the thermo-cautery. Recovery, irrigation with permanganate of potash excites cough, drains removed thirty-six days after the operation; eighteen months after recovery slight scoliosis and scar, depressed respiration, feeble on the operated side.

Case 25, 1888. O'Keel, Lancet, 1888, Vol. 1, p. 622. Pulmonary gangrene; several weeks duration; pleuro-pneumonia; right base; adhesions. Pneumotomy. Recovery.

Case 26, 1888. Pollard, in Pasteur Chir. Soc. of London, 1888, in British Med. Jour., 1888, Vol. 2, p. 279. Male, 7 years. Gangrene; Three weeks duration. Pneumonia, probably secondary to a foreign body; right apex anteriorly. Signs of cavity. Incision in the second interspace, enormous cavity; counter-opening in sixth interspace. Death on thirteenth day. Necropsy: Cavity occupying one-third of the center of lung (the three lobes affected), esophagus adherent to the right bronchus and communicating with the same, cause of this communication unknown.

Case 27, 1888. Page, London Lancet, 1888, Vol. 1, p. 572. Male, 13 years. Pulmonary gangrene with hydropya-pneumothorax; run over by a car. Signs of cavity, probably due to pneumothorax. Aspiration, 20 ounces of sanguinous serum. Pleura opened and tube inserted in fifth left interspace in mid-axillary line, offensive pus evacuated, tube taken out about one month after operation; immediate improvement; discharge lessened daily, piece of pleura and lung discharged, complete recovery.

Case 28, 1888. Pasteur, Brit. Med. Jour., 1888, Vol. 2, p. 879. Male, 7 years. Gangrene of lung; four weeks duration; insidious onset but had developed rapidly; right upper lobe. Signs of cavity. Cavity incised out extreme of right second space one inch from sternum, large quantities of gangrenous lung and putrid fluid were expelled, cavity reached to sixth rib, opening made in sixth space, and drainage tube inserted. cavity washed out twice daily, pus appeared later. Next morning patient much relieved; expectoration small quantities of frothy spits, free from pain; improvement not maintained; after ten days fetor and temperature reappeared; patient sank rapidly three days later. Necropsy: Huge cavity occupied anterior one-third of lung (right) lined with thin layers of granulation tissue, pericarditis present, esophagus adherent to bronchus, commenced between esophagus and right bronchus.

Case 29, 1888. Seitz, Inaug. Dissert., Würzberg, 1888. Male, 35 years. Acute gangrene; five weeks duration; typhoid fever six weeks; left base posteriorly. Signs of cavity; adhesions. Resection of seventh and eighth ribs, 4 cm., incision of lung with bistoury, cauterization, drainage. Death twelve days after a second cavity containing 250 grams was discovered. Necropsy: A right pulmonia and cathesia.

Case 30, 1888. Shewen, Aust. Med. Gaz., Sydney, 1888-89, Vol. 8, p. 173. Gangrene; pneumotomy. Recovery.

Case 31, 1889. Bastcanelli, Bull. de Soc. Lanc. de Osp. Roma, 1889-90. Vol. 10, p. 35. Female, 34 years. Acute gangrene; duration one month. Septicemia following ovariotomy; right base axillary line. Resection of fifth and sixth ribs in axillary line, puncture cavity 1½ cm. deep, irrigation of cavity, syncope, tamponade. Death fourteen hours later, coma left hemiplegia. Necropsy: Embolism of sylvain artery, thrombosis of a pulmonary vein.

Case 32, 1889. Freiberg, Meditzina, St. Petersburg, 1889, Vol. 1, No. 50, in Chictuertink, 1894, p. 763, Observation 41. Male, 26 years. Fetid abscess with hemoptyses; two months duration. Acute frank pneumonia; left base posteriorly. Signs of cavity; doubtful adhesions. Incision internal to the lower angle of the scapula; resection of the sixth rib, pelves thickened where there has been applied a paste; enlargement of the opening with the cautery, cavity 3 cm. deep, into which the bronchi opened, drainage and iodoform gauze. Death sixteen days later, septicemia. Necropsy: Purulent and hemorrhagic pleurisy, septic lobar pneumonia, multiple adhesions, the cavity the size of a fist.

Case 33, 1889. Ramsay, Annals of Surg., 1889, Vol. 2, p. 144, and 1890, Obs. 2. Male, 25 years. Gangrenous abscess; four weeks duration. Injury by forearm of thorax and lungs; axillary region and anteriorly. Signs of

cavity; adhesions. Thoracotomy, resection of the second, third, fourth, fifth, sixth and seventh ribs, pneumotomy, issue of pus and of débris of garments. Recovery.

Case 34, 1889. Smith, S. C., Lancet, 1889, Vol. 2, p. 113. Female, 39 years. Gangrenous abscess; duration five weeks. Pneumonia for three weeks; right base posteriorly. Signs of cavity; adhesions. Exploratory puncture at the angle of scapula without result. Incision without rib resection at lower angle of scapula, dilatation of a focus opening of a small cavity. Recovery with fistula in four weeks.

Case 35, 1889. Von Openschouski, Zeitschrift für Klin. Med., Berlin, 1889, xvi, 393 and 398; Male, 30 years. Lung abscess and gangrene, three weeks after onset coughed up cup of fetid pus, no tubercle bacilli; four months duration. Exposure and cold; right side middle lobe. Signs of cavity; pleural adhesions; Negative puncture on right side, repeated punctures a week later give negative results. Incision between mammillary and hind axillary line over fifth and sixth ribs were excised to extent of 10 cm.; opened directly into lung with thermo-cautery, at depth of 2 or 3 cm. cavity was opened, patient coughed and emptied out of wound a greenish, fetid pus; lining of cavity suspended with fingers, cavity irrigated with dilute potassium permanganate sol., drainage and antiseptic packing, wound irrigated twice daily at first and daily later. Recovery; patient discharged as cured seven months after admittance.

Case 36, 1889. Walsham (Symonds), St. Bartholomew Hosp. Reports, 1889, Vol 25, p. 253. Male, 33 years. Acute gangrene; seven weeks duration. Pneumonia, aspiration of material (submission); left base posteriorly. Rib resection, drainage and irrigation. Improvement; death five weeks after, hemoptysis from the pressure of the drain. Necropsy: Cavity diminished in size.

Case 37, 1890. Anderson, Am. Pract. and News, Louisville, 1890, Vol. 10, p. 10. Male, 32 years. Gangrene cavity; forty-five days duration. Pneumonia; lower lobe. Puncture in sixth interspace, one inch behind axillary line, pus. Incision two inches long over seventh interspace, one inch behind axillary line, down to intercostal muscles; inserted trocar five inches long, blood; inserted needle and obtained pus; reinstated trocar into cavity and drew off one pint pleurant matter; dilated opening with forceps, introduced rubber tube, irrigated next day, some fluid passing into trachea. Recovery; cough ceased.

Case 38, 1890. Ramsay, Annals of Surg., 1890, Vol. 2, p. 34. Male, 32 years. Gangrene. Acute pneumonia; right base posteriorly. Signs of cavity; adhesions. Exploratory puncture positive. Incision and resection of 3 cm. of seventh rib, puncture incision above the trocar with the bistoury and forceps, issue of gangrenous liquid, drainage. Recovery in six months, the drain removed the seventh day but was replaced on account of retention, no fistula.

Case 39, 1891. Fenger and Hollister, Münch. Med. Woch., 1891, p. 8. Male, 34 years. Gangrenous abscess. Suppurating hydatid cyst; lower lobe. Signs of cavity. Exploratory puncture. Incision of the third interspace anteriorly, counter-opening in fifth interspace in axillary line. Recovery in six weeks.

Case 40, 1891. Krecke, Münch. Med. Woch., 1891, Vol. 38, p. 399. Male, 20 years. Gangrene of lung, purulent pleurisy. Stricture of esophagus from alkali poisoning, unable to pass tongue; right side empyema and gangrene lower lobe. Esophagotomy, external resection of ribs for empyema; gangrenous area was opened, cavity discovered the size of a chicken's egg. Patient died six hours later.

Case 41, 1891. Krecke, München Med. Woch., 1891, p. 399. Female, 15 years. Gangrene. Stricture of the esophagus, treatment by esophagotomy; right base posteriorly. Pneumotomy. Death from exhaustion. Necropsy: Multiple abscesses in the left lung, the right cavity cicatrizing.

Case 42, 1891. Porter, Journal of Am. Med. Ass'n., 1891, Vol. 16, p. 335. Young female. Gangrenous abscess. Grippe after confinement; left base. Signs of cavity; adhesions. Incision and rib resection, irrigation, drainage. Complete recovery.

Case 43, 1891. Ochler, München Med. Woch., 1891, p. 713. Male, 30 years. Chronic gangrenous abscess; two years and seven months. Pleuro-pneumonia two years previously, expectorate gangrenous and hemoptoic; left base posteriorly. No signs of cavity except for one month; no adhesions. Resection of the seventh rib, pneumothorax; the operation abandoned; drainage of the pleura, pneumothorax absorbed within a few days; four weeks later a new incision at the same point and depth of 5 cm. in the lung; the cavity opened spontaneously into the liver, two days later drain-

age. Recovery, purulent fistula one and a half years later; the patient has been troubled since his fistula closed (fetid sputum fever).

Case 44, 1891. Porter, Journal Am. Med. Ass'n., 1891, Vol. 16, p. 335. Male, middle-aged. Gangrenous abscess; left base. Signs of cavity, abscess contains gas; adhesions. Incision and rib resection, irrigation, drainage. Complete recovery.

Case 45, 1891. Thue, Nordiski-Magaz., 1891, p. 771, in Johnesbericht, 1891, Vol 11, p. 445. Male, 37 years. Gangrene. Acute bronchitis and double pleurisy; right apex; partial adhesions, insufficient. Resection of the third and fourth ribs, lungs fixed in the incision by sutures because of the insufficiency of the adhesions. Purulent pleurisy, death three and a half months later. Necropsy: Purulent pericarditis.

Case 46, 1892. De Cerenville and Roux, Rev. Méd. de la Suisse, Romande, 1892, p. 233. Male, 53 years. Acute gangrene; four weeks duration. Bronchiectasis; left base anteriorly and in axillary line, disseminated foci. Signs of cavity. Pneumotomy in extremis, resection of fifth rib, axillary line opening with a cautery, a large cavity. Death a few hours later Necropsy: Bilateral bronchial dilatations, gangrenous cavity of left base.

Case 47, 1892. De Cerenville and Roux, Rev. Méd. de la Suisse, Romande, 1892, p. 229. Male, 18 years. Acute gangrene; eight weeks duration. Grippe in 1889; bronchitis; right base posteriorly. Signs of cavity; partial adhesions. Puncture, serous fluid. Resection of 6 cm. of ninth rib, partial pneumothorax, lung grasped with forceps, immediate suture of two pleuræ; purulent pleurisy eight days later; puncture, pus; pleurotomy sixteen days later complete pneumothorax, second pleurotomy. Recovery; seen nine months later, cured with excavation.

Case 48, 1892. De Jersey, W. B., Lancet, Vol. 1, 1892, p. 21. Child 21 months. Gangrene of lung; six weeks duration. Pneumonia, history phthisis; left side. No signs of cavity positive; pleural adhesions. Puncture in left chest rib, sixth space, axillary line, and in same space to angle of scapula, pus was withdrawn. Incision in sixth space between post and mid-axillary lines, one dram of pus of fetid odor escaped; temperature fell after operation. Death three days after operation. Necropsy: Left lung solid, tubes thick and containing pus, scattered particles of gangrene; bronchitis.

Case 49, 1892. De Beurman, same. Female, 12 years. Gangrene. Bronchopneumonia or suppurative interlobar pleurisy; middle lobe of right lung. Signs of cavity. Resection of fifth and sixth ribs, incision with thermocautery through 3 cm. of lung tissue, large drain, irrigation. Recovery.

Case 50, 1892. Delagruien, Cong. Trans. de Chir., 6, 1892, p. 583. Male, 37 years. Gangrene of lung; ten months duration. Fall upon chest; base of left lung. Trocar finds pus, puncture at level of ninth rib. Resection of seventh, eighth and ninth ribs in their entirety from posterior angle, opening of abscess, escape of one-half liter of greenish, fetid pus, irrigation of cavity with 1 oz. Cl., 1 to 2000, drainage. Recovery; drainage tube removed twenty-seven days after recovery; fistula.

Case 51, 1892. Hagen, Thomwratch, 1891. and Meditzina, St. Petersburg, 1892, Vol. 4, p. 455. Male, 32 years. Gangrenous abscess. Fibrinous pneumonia; right base anteriorly. No signs of cavity; adhesions. Exploratory puncture, fetid pus. Incision of 5 cm. in the fourth interspace. Recovery in one month.

Case 52, 1892. Monod, Soc. de Chirurgie, 1892, p. 578, and 1895, p. 733. Male, 48 years. Acute gangrene; twenty days duration. Pneumonia, two months duration; left base posteriorly. Signs of cavity; adhesions (not diagnosticated). Exploratory puncture in ninth interspace negative, puncture in eighth interspace positive. Pneumotomy without rib resection at the level of eighth interspace, abscess situated at depth of 10 cm. Recovery in one and a half months.

Case 53, 1892. Perier and C. Paul, Bull. Acad. de Méd., 1892, Vol. 27, p. 375. Male, 58 years. Gangrene; four months duration. Bronchitis and gangrenous septicemia seven months previously; left apex. Signs of cavity; loose adhesions. Incision in the second interspace, focus and depth of 2 cm. containing 60 c.c. of pus, drainage (naphthol camphor). Recovery in fifty days.

Case 75, 1893. White, Medical News, 1893, Vol. 62 p. 38. Female, 30 years. Chronic gangrene (first focus), second focus three and a half months since; three and a half months duration. Old infectious pneumonia, acute pleuropneumonia; right base anteriorly and posteriorly. Signs of cavity; adhesions. Exploratory puncture positive. Incision in sixth interspace, two ounces of fetid pus, irrigation, drainage; incision of rent in post-axillary line sixth interspace, issue of several ounces of fetid pus and fragments

of gangrenous lung. Cured, two months drain removed, cured in eight months; observed two years after, cured.

Case 54, 1893. Hofmakl, Wiener Klin. Woch., 1893. Male, 25 years. Gangrenous abscess, putrid bronchitis; one month duration. Bronchitis; left apex anteriorly. Signs of cavity; adhesions. Incision in the second interspace, cavity not opened; six days later resection of 8 cm. of third rib; puncture of lung, at third puncture issue of air and secretion upon dilatation of tract; hemorrhage arrested by tampon. Recovery in one and a half months without fistula.

Case 55, 1893. Tizebicky, Wiener Med. Woch., 1893, Nos. 21 and 22. Male, 58 years. Chronic gangrenous abscess; three months duration. Traumatic pneumonia three months previously; right base anteriorly. Signs of cavity; adhesions. Exploratory puncture. Resection of the fourth rib (4 cm.); two days after the puncture opening of a gangrenous cavity. Death sixteen hours later.

Case 56, 1894. Grube, in the Clin. Viestinik, 1894, p. 63, observation not published. Male, 42 years. Gangrenous abscess, no bacilli of tuberculosis; two years duration. Fibrinous pneumonia; right upper lobe anteriorly, thorax retraction. Signs of cavity; adhesions. Incision in second interspace; exploratory puncture with hypodermic needle, issue of pus; incision of parenchyma with cautery to depth of 6 cm., small, insignificant cavity; five days later the larger cavity opened spontaneously through the incision, no drainge, strand of gauze. Recovery; he left hospital one and a half months later with a wound on its way to cicatrization.

Case 57, 1894. Habershou, Lancet, 1894, Vol. 1, p. 1012. Male, 32 years. Gangrene of lung; six months duration. Syphilis; left apex and right base, advanced toward bases. Signs of cavity; pleural adhesions. Positive puncture. Portion of rib resected, but little pus obtained. Patient died a short time after operation. Necropsy: Right lung firmly adherent posteriorly, pleura thickened, extreme apex fairly healthy, though emphysematous; posterior two-thirds of lung a series of red eating cavities; in left lung broncho-pneumonia, gangrenous patch; tubercle bacilli found, also giant cells.

Case 58, 1894. Priestly, Teck, Lancet, Vol. 1, p. 87. Male, 22 years. Chronic abscess complicated with secondary gangrene; four months duration. Pleuro-pneumonia, six months duration; left side anteriorly. No signs of cavity; adhesions. Incision in third interspace; multiple punctures (5), negative puncture in second interspace, the second puncture brought pus; incision with the trocar; dilatation with the forceps of Lister, pus, drainage. Recovery after having hemoptyses twice during convalescence; complete recovery six months after.

Case 59, 1894. Mackay, Inter Col. of J. F. M. and S., Melbourne, 1894, Vol. 1, p. 52. Male, 12 years. Gangrenous abscess, hemoptysis; Several days. Acute pulmonary affection of five weeks duration; no diagnosis; right base antero-laterally. No signs of cavity; adhesions. Puncture negative. Incision below the lower border of the scapula; resection of two ribs, adhesions; multiple punctures in all directions, at last upon finding a small cavity the size of a walnut containing gangrenous débris, this cavity was incised. Death, hemoptysis. Partial Necropsy (lung only): The upper lobe normal, the lower and middle lobes adherent; a cavity, the size of an orange opened, separated by thicknesses of 3 mm.; five or six other small abscesses of lower lobe, abscess of the middle lobe.

Case 60, 1894. Rodman, Am. Prac., Louisville, May 5, 1894, in Chir. Am., 1895. Young male. Acute gangrene. Infectious pneumonia following a fracture of the ribs. Incision and resection of sixth rib twenty days after the accident (four inches), pus and pulmonary débris; repeated tamponade. Recovery.

Case 61, 1894. Rochet, no date, given immediately under another dated May, 1894. Local gangrene. Resection. Recovery.

Case 66, 1894. Rochet, Inaug. Dissert., Kiel, 1894. Male, 28 years. Gangrenous abscess, gangrenous pneumonia; three weeks. Old bronchial dilatations; third interspace anteriorly, right base posteriorly. Signs of cavity; no pleural adhesions. One puncture in the ninth interspace negative, one puncture in the third interspace anteriorly positive. Application of a paste of chlorid of zinc; resection of 3½ cm. of the third rib; spontaneous opening of the cavity ten days later; ten weeks later the same operation posteriorly at level of fifth rib, opening of cavity on seventh day. Death two days after opening second cavity. Necropsy: Old bronchial dilatation, broncho-pneumonia cachexia; the patient improved after first operation, failed after second

Case 62, 1895. Bazy, Soc. de Chirurgie, 1895, p. 69. Male, 20 years. Gan-

grene; right base; partial adhesions. Incision 10 cm. long parallel to the ninth rib, which is resected as well as the eighth (6 cm.); digital exploration through a small opening in pleura, adhesions above the incision, second incision above the first; pleural adherent gangrenous focus, 12 cm. deep. Cured in twenty days. Death three or four months later from epilepsy.

Case 63, 1895. Harrison, in Quincke Mittheil Aus. den Greug., 1895, Vol. 1, p. 1011, table 1 b, observation 1. Female, 27 years. Gangrenous abscess; six days duration. Pulmonary embolism following puerperal fever of three weeks standing; right base posteriorly. No signs of cavity; adhesions. Exploratory puncture. Resection of four cm. of the ninth rib, opening of the cavity containing 300 c.c. of pus. Death three days later. Necropsy: Pyemia.

Case 64, 1895. Krause, Berliner Klin. Woch., 1895, p. 347. Male, 36 years. Chronic gangrene; nine months duration. Infectious pneumonia; left base posteriorly; no adhesions. Resection of 12 cm. of ninth and tenth ribs, opening of the pleura; the upper lobe retracted, the lower lobe adherent to the thorax, tamponade with iodoform gauze; five days later sufficient adhesions except at one point (above); opening of the cavity, cavity the size of an apple, gangrenous fragments of lung, two drains. Recovery; the bronchial fistula closed twenty-five days later; three and a half months later cured a little roughness of respiration, and amplitude of thorax slightly diminished.

Case 65, 1895. Krause Berliner, Klin. Woch., 1895, p. 347. Male, aged 33 years. Purulent pleurisy; gangrenous abscess(?); three months' duration. Bronchitis and right side pleurisy; right base anteriorly; adhesions, Resection of fourth and fifth ribs in the maxillary line; pulmonary fistula; pneumotomy; at 2 cm. we come upon a cavity the size of an egg; tamponade. Recovery; left the hospital three weeks after the operation, wound healing.

Case 67, 1895. Podieze, Rev. Gende Chir. et de Ther. Jour. des Praticiens Paris, Nov. 19, 1895. Gangrene of left lung. Incision 12 cm. long from above down in left subclavicular region; excised 3 cm. of second and third ribs; sutured pleural transverse incision in lung; fetid pus escaped; walls of cavity swelled; irrigation with Thiersch sol.; iodoform tampon. After third dressing pus lost fetor. Wound healed in three weeks. In forty-five days after operation patient had gained thirty-one pounds.

Case 68, 1895. Quincke, Mittheilunzen ano der Grez geb den Medici und Chir., 1895, Bd. 1, H. T. 1, obs. 6, p. 25, and Tab. 2, observation, 8, pp. 30-31. Male, aged 34 years. Chronic putrid abscess; duration one and one-half years; pneumonia complicating grip; left base and the axillary line; signs of cavity; adhesions. Resection of the third rib in the axillary line anteriorly; opening of cavity. Death one and one-half hours later. Necropsy: Several cavities if only opened; death from exhaustion; recent gangrene in right; pleural exudate in the right.

Case 69, 1895. Quincke, ibid., Bd. I, H. T. I, Tab. 1, observation 6, pp. 10 and 11, and obs. 1, p. 8. Male, aged 33 years. Acute gangrene (gangrenous abscess); duration four weeks; acute pneumonia two and one-half years; right base posteriorly; signs of cavity; adhesions. Exploratory puncture; issue of pus. Resection of eighth, ninth and tenth ribs (6 cm. in the scapula line); H-shaped incision at level of ninth rib; two sutures of lung to the pleura; multiple exploratory punctures without result; three days later a purulent fistula formed; opening enlarged with the cautery; five days later rib resection; drainage. Recovery in six weeks; completely cured in two months.

Case 70, 1895. Quincke, ibid., 1895, Bd. I, Ht. I, obs. 5, p. 23 and Tab. 2, pp. 28–29. Male, aged 39 years. Chronic gangrenous abscess with secondary bronchiectasis; duration ten months; left base posteriorly; signs of cavity; partial adhesions ascertained by the puncture. Exploratory puncture in fifth interspace, axillary line; pus, sero-sanguinous fluid. Application of paste of chlorid of zinc; resection of 3 cm. of sixth rib fourteen days later; puncture; pus; opening of the cavity with cautery. Death three days later. Necropsy: Sero-purulent pleurisy; encysted in the left; multiple cavities; chronic meningitis.

Case 71, 1895. Tuffier, Soc. de Chir., 1895, p. 769, obs. 1. Male, aged 59 years. Acute gangrene, fifteen days duration. Infectious pleuro-pneumonia of forty-five days' duration; right base in axillary line; signs of cavity; no adhesions. Incision in sixth interspace without rib resection; complete pneumothorax; total retraction of the lung; impossible to open the lung; drainage of the pleura. Recovery.

Case 72, 1895. Tuffier, Ibid., 1895, p. 767, obs. 5. Female, aged 19 years. Gangrene of three months' duration. Acute pneumonia and pyemia since

three and one-half months; right apex anteriorly; signs of cavity; partial adhesions. Incision at level of third interspace; no adhesions at this point; separation of the parietal pleura adhesions at the level of second rib; resection of 5 cm. of this rib; pneumotomy; opening of a cavity the size of head of fetus; tamponade. Death fifteen days later; meningo-encephalitis. No necropsy at the time of operation; the patient presented the accidents of gangrenous embolism of the sylvan artery; this suddenly the same day as the pneumotomy and as the trephining of the head.

Case 73, 1895. Tuffier, Ibid., 1895, pp. 676 and 769, obs. 4. Male, aged 60 years. Acute gangrene of six weeks duration. Pneumonia; right base posteriorly; no signs of cavity; partial adhesions. Incision in eighth interspace; separation of the parietal pleura adhesions at level of the seventh rib; resection of seventh rib; opening of a cavity the size of a fetus head; tamponade. Death six days later; cause, hemoptysis. Necropsy: Hemorrhage in the center of the cavity; no pleurisy or pneumothorax.

Case 74, 1895. Tuffier, Ibid, 1895, p. 771, obs. 5. Male, aged 41 years. Acute gangrene of three weeks duration. Pneumonia of four months; right base anteriorly; signs of cavity; adhesions. Incision below the fourth rib within the nipple; no rib resection. Death five days later; hemoptysis. No necropsy.

Case 76, 1896. Duret, Arch. de Medicine, 1896, Vol. 1, p. 67. Female, aged 21 years. Chronic gangrene of the lung. Old bronchiectasis; right base posteriorly; signs of cavity; positive puncture. Rib resection (three ribs), 7 to 8 cm.; incision of the pleura; pneumotomy; opening of a cavity the size of a hen's egg, into which opened two bronchi; cauterization; drainage. Amelioration; recurrence nine months later; curettage of the cavity; counter-opening; drainage; fistula resulted, which was operated on with success four years later. Complete recovery two and one half years after last operation.

Case 78, 1896. Meakin, Brit. Med. Jour., 1896, II, p. 746. Female, aged 31 years. Probable gangrene of pleura and lung of a few days' duration. Acute pneumonia; adhesions. Sixth and seventh ribs resected in anterior axillary line, one-half inch from each; pleural cavity opened; grayish-black very fetid fluid escaped from lung; did not collapse; lung was hard except one spot, which was doughy; in this spot a forceps was plunged, followed by a drainage. Distress diminished steadily; recovery after first few hours; discharge dark red, tarry quality, becoming like pus; discharge after first four days was not fetid.

Case 79, 1896. Phillips and Nash, Lancet. 1896, Vol. 21, p. 1454. Male, aged 36 years. Acute gangrene of one month. Pluro-pneumonia; right base in axillary line; no signs of cavity; adhesions. Exploratory puncture; pus, blood, débris. Incision in the sixth interspace; resection of one and one-half inches of sixth rib; gangrenous cavity; débris of neurotic lung; irrigation; no improvement; one month later resection of seventh and eighth ribs, two inches (posterior axillary line); numerous exploratory punctures without result; no cavity. Recovery fourteen months; purulent discharge through the wound at several relapses; drain one year; hemoptysis thirteen months after the operation. Complete recovery; seen four years later.

Case 80, 1896. Smith and Treve, Lancet, 1896, Vol. 2, p. 532. Male, aged 40 years. Gangrenous abscess of one and one-half months. Acute pneumonia; between inner border of scapula and spine; no signs of cavity; adhesions. Negative exploratory puncture two days before operation. Incision and resection of rib; opening of a small abscess. Recovery, but later relapse and formation of a second abscess at the site of the first, which is opened and drained.

Case 81, 1896. Smith and Treves, Ibid, p. 522. Male, aged 45 years. Fetid gangrenous abscess of four months duration. Pleuro-pneumonia; posteriorly below the angle of the scapula; signs of cavity; partial adhesions. Incision and rib resection; exploratory puncture negative; cavity the size of a cricket ball; pleura not adherent at the base; protected with tampon. Death twelve days after a second cavity containing 250 grams was discovered. Necropsy: A right pneumonia and cachexia.

Case 82, 1897. Andrews in Morillon These de Paris, 1897, p. 71, observation 2. Male, aged 42 years. Gangrenous abscess of fourteen weeks' duration. Pneumonia; left base anteriorly and laterally; no signs of cavity; adhesions. Resection of 8 cm. of fifth rib in axillary line; puncture; pus 8 cm. deep; incision and curettage of cavity; during the operation syncope caused by an embolism of lung tissue. Improvement; the patient was lost sight of before recovery was complete.

Case 83, 1897. Andrews in Morillon These de Paris, 1897, p. 75, obs. 5. Male, aged 24 years. Gangrenous abscess of two years' duration. Pneu-

monia; left lower lobe; signs of cavity; adhesions. Resection of 2 cm. of two ribs in axillary line; incision of lung with the bistoury; cavity 4 cm. deep, contained necrotic lung tissue; iodoform dressing. Rapid recovery. Death two years later; cerebral syphilis probable cause.

Case 84, 1897. Bazy, Soc. de Chirurgie, 1897, p. 67. Gangrene; adhesions. Pneumotomy; extraction of 32 grams of shreds of pulmonary sloughs. Result unknown.

Case 86, 1897. Jagle et Raffray in Morillon th. Paris, 1897, p. 105, et Soc. Aust., 1893. Female, aged 41 years. Acute gangrenous abscess, putrid expectorate; thirteen days duration. Acute frank pneumonia six weeks before; right base posteriorly; signs of cavity; adhesions; two negative punctures. Incision in the eighth interspace (cocain anesthesia); puncture of the pleura negative; incision; a violent cough brings forth two to three spoonfuls of fetid pus; irrigation with sublimate provokes violent cough; issue through the wound; two pulmonary sloughs; two drains. Improvement for three days; death the fourth day. Necropsy: Cavity in the right lower lobe posteriorly, into which many bronchi open.

Case 87, 1897. Lapujko, Soc. de Med. des Kiefin, Wratch, 1897, p. 173. Female. Gangrene; pneumotomy; cured several months.

Case 88,.1897. Lapujko, Ibid., Wratch, 1897, p. 173. Male. Gangrene; pneumotomy (several fragments of lung); recovery.

Case 89, 1897. Tejars, Soc. de Chirurgie, 1897, Feb. 17, and Gaz. Hebd. de Medicin et de Chirurgie, 1897, p. 181. Male, aged 50 years. Pulmonary gangrene with an arterio sclerosis and general paralysis. Few signs of cavity; partial adhesions, inextensive at the level of gangrenous focus. Resection of three ribs, fourth, fifth and sixth; pleuro-parileta separation; incision of the pleura; lung held with forceps and explored; opening of a cavity the size of a hen's egg at depth of 1.5 cm.; suture of lung to parietal pleura. Death two days later from exhaustion. Necropsy: No other gangrenous cavities.

Case 90, 1897. Tejars. loc. cit. Male, aged 33 years. Pulmonary gangrene, acute, eight days' duration. Infectious broncho-pneumonia of two months; right base posteriorly; no signs of cavity; loose partial adhesions. Incision; separation of the pleura; pneumotomy at a point; adhesion; the cavity not found. Death of infection two days later. Necropsy: The cavity is located in the apex; cavity also at the base.

Case 91, 1897. D. M. Moie, London Lancet, 1897, Vol. 1, p. 105. Male, aged 23 years. Gangrene of lung of forty-five days' duration. Acute pneumonia of left lung; adhesions. Horizontal incision two inches long in fifth interspace of left side; escape of fetid fluid and débris; drainage tube; tube removed three weeks after and wound closed one month after. Complete recovery.

Case 92, 1897. Welkowitch, Soc. de Med. de Kieff in Wratch, 1897, p. 175. Male, aged 35 years. Acute gangrene of one month duration. Pneumonia, but no bacilli of Koch; right base anteriorly; signs of cavity; adhesions. Resection of 6 cm. of fifth rib; opening of a cavity, long and narrow, counter-opening posteriorly at the ninth rib, which leads to a pocket the size of an infant's head; these two cavities are separated one from the other. Probable recovery.

Case 93, 1897. Northrupaud Medicle. N. Y. Med. Jour., Jan. 14, 1897. Female, aged 33 years. Gangrenous abscess of three months' duration. Pleuro-pneumonia; influenza; fetid bronchitis; right base anteriorly; no signs of cavity; partial adhesions, absent anteriorly. Puncture at level of third interspace at the axillary line; many punctures below nipple without result. Incision and resection of sixth rib (3.5 cm.) in the axillary line; partial pneumothorax (not alarming); puncture of the lung; pus at depth of 2 cm.; incision with the scissors; three ounces of pus and gangrenous fragments of lung; second abscess above the first also opened. Recovery; frequent hemoptysis during convalescence; wound completely closed in three months; no hemorrhage; no irrigation; drainage. After nine months acute extension with fetid expectorate at this time; recovery without intervention.

Case 94, 1897. Pitts, London Lancet, Vol. 2, p. 915. Child, aged 4 years. Gangrenous abscess of six weeks' duration. Caseous mediastinal glands; left side; pleural adhesions. Rib resected; exploration failed to reveal cavity in lung. Death nine weeks after operation. Necropsy: Caseous bronchial glands, which had opened into esophagus and left bronchus tubercular glands of neck and mediastinum.

Case 95. Pitts, London Lancet, Vol. 2, p. 915. Child, aged 5 years and nine months. Breath fetid, temperature high; hemoptysis had occurred. Caseous mediastinal glands; posterior part of right lung; signs of cavity; pleural adhesions. Exploratory punctures through incision failed to

reach cavity. Excision of sixth and seventh ribs in right interscapular region; lung adherent. Child collapsed and died several hours after operation. Necropsy: Caseous abscess cavity size of walnut at root of right lung, opening into right bronchus; caseous glands close to abscess; no signs of tubercle; several patches of gangrene apart from abscess cavity.

Foreign bodies.—The subject of foreign bodies in the bronchi is treated here after abscess and gangrene, as they frequently result in abscess and gangrene. A great variety of foreign bodies have been aspirated or thrown into the bronchi. The most common variety, in America at least, as taken from the statistics of Dr. Weist, who collected over a thousand cases (Trans. Am. Surg. Ass. 1881), is a grain of corn; in frequency this variety is followed by inhalation of the various seeds, as melon, pumpkin, orange, etc., beans, buttons, pebbles and marbles. The effects produced by these foreign bodies on the lung may be divided into primary and secondary. The primary are the dyspnea, pain and coughing; the former may be mild or intense, even to death, depending on the size and location of the body; the pain is usually very severe, and is often a guide to the location of the body; the coughing is persistent, and is often associated with pain. If the body be smooth and of regular outline it may prevent the admission of air to a lobe or even to an entire lung, and by the frequent efforts of coughing and the ball valve action of the body, the lung may be emptied of air and inspiration made painful and distressing; the foreign bodies are retained in their position, principally by the edema of the mucosa; occasionally by the swelling of the seed. Weist's statistics show that the seeds, for the number aspirated, do the least harm; they are the most difficult to find in operation, and therefore should not be operated except when especially indicated. The body may be arrested in the larynx, trachea, at the bifurcation or in a bronchus. Numerous statistics have been published to show that the foreign body has been arrested most frequently in the right bronchus. A comparison of all statistics shows that the arrest occurs in the right and left bronchus with almost equal frequency. The location of the foreign body can often be ascertained by the physical signs. We can at least determine which

bronchus is occluded. We are now greatly relieved of the uncertainty of location by the assistance of the X-ray. Many methods have been suggested for the primary treatment of these cases: one of the best is taking advantage of gravity early in the case, *i. e.*, holding the patient by the feet, requiring him to cough as deeply as possible, and slapping the chest forcibly at the time of expiration; this often forces the foreign body out of the bronchus. In upward of 60 per cent. of the recorded cases the foreign body was expelled in this way; as many of these cases are never recorded or even come under a physician's care, it is certain that a much larger percentage recover by this method. Tracheotomy for foreign body has given very good results, but should not be practiced until other means have failed. When the tracheotomy was successful in the removal of the foreign body, the mortatity was 6 per cent. When unsuccessful 21.5 per cent. (Weist).

The secondary effects of foreign bodies in the bronchi are even more serious than the primary, as they induce infective processes—abscess, gangrene, bronchiectasis and tuberculosis, which terminate fatally. When it is a metallic or dense substance it can be readily located in a radiograph. The outlines of the abscess can also be defined by this means. G. A. Sutherland reports an instructive case of bronchiectasis, a sequence to an inhaled O'Dwyer tube. The bronchiectatic cavity was opened and the foreign body was not found. The patient died of hemorrhage about three weeks later. Postmortem showed the tube in the right upper bronchus. Multiple bronchiectatic cavities were found.

The following case illustrates the secondary effects of foreign bodies:

Case 1.—March, 1886, Katie M., aged 14, was brought to my office suffering from dyspnea and constant bronchial irritation, following the inhalation of a shelled peanut. It was believed to be in the bronchus of the middle lobe of the right lung; the inhalation was followed by consolidation of this lobe; the expectoration was not offensive, but sero-purulent, tinged with blood. Three weeks later, in a severe attack of coughing, the patient ejected the peanut. The expectoration from that time was scanty but continuous; it was not offensive; the consolidation did not disappear. Six months later

she called at my office again; I found her suffering from an acute pulmonary tuberculosis. There was a cavity in the middle lobe of the right lung and bacilli were present in the sputum. Patient died two months later. No postmortem was made. I believe that the foreign body produced the *locus minoris resistentia* for the tubercular infection.

I recall a postmortem made during my interneship in 1879, in which a 6-penny shingle nail was the foreign body and the exciting cause of the tuberculosis. The literature on tuberculosis abounds with cases of this class, and the secondary results of foreign body in the lung must not be overlooked though the patient escapes the gangrene and abscess as earlier results.

The presence of a foreign body in the bronchus should be a source of great anxiety until it is removed. The method of its removal has offered fruitful material for speculation and experiment. Primary opening of the bronchus and trachea has been suggested and executed successfully, but the percentage of cases in which the foreign body has been found in the operation has been small, and the results of primary anterior or posterior bronchotomy or pneumotomy do not justify the operation although it often seems indicated. (Truc.) DeForest Willard made extensive and praiseworthy experiments on the removal of foreign bodies in animals, and came to the conclusion that bronchotomy for the removal of foreign bodies should not be attempted. Of 11 operations collected by Tuffier there were four immediate deaths, and in only one of the 11 was the foreign body recovered at the time of the operation. The other cases made only temporary recoveries or had fistulæ. The dangers of bronchotomy are, hemorrhage, pneumothorax and infection. From the results of operations and experiments we are not justified in operating for the removal of the foreign body *per se*. These cases should be carefully watched, and early intervention should be made when the secondary changes have taken place, as abscess and gangrene.

TUBERCULOSIS.

Tuberculosis of the lung has been considered a medical and not a surgical disease. In a few instances the surgeon has had the courage to open and drain tubercular cavities in the lung; in a still smaller num-

ber he has excised a portion of the lung for the removal of a circumscribed tubercular nodule. Wm. Koch suggested the injection of disinfectants and chemical irritants into the diseased portion of the lung, but they have been used to a very limited degree. With these few exceptions, the disease has been left entirely to the care of the physician. We ask ourselves, what has been achieved in tuberculosis? With the exception of a thorough knowledge of its etiology and pathology, comparatively nothing. We have volumes of literature on the subject, describing its various phenomena, course and terminations. From a sanitary standpoint, since Villemin in 1865 showed its infectious character and Koch discovered the particular bacillus, we are possibly lessening the number of infected; from a therapeutic standpoint we had hoped, and still hope, that tuberculosis may be cured, alleviated or curtailed in its destructive effect by products derived from the tubercular bacillus under certain conditions. The results barely justify a continuation of the hope. Can surgery contribute anything toward the repair of tubercular lesions of the lung? It has accomplished much in the treatment of tubercular lesions of the articular and osseous systems; its results in the treatment of tuberculosis of the peritoneum have been little less than brilliant. The ideal treatment of tuberculosis is eradication; extirpation of the tubercular focus. In only a few instances has the surgeon been able to attack it so as to obtain this ideal result, as in cutaneous, synovial and osteo-tuberculosis. His best achievements have been obtained in cases where he merely placed the tissues under favorable conditions for repair by nature, as drainage of the peritoneal cavity with or without extirpation of the original focus of infection. This necessarily demands the consideration and reparative power of individual tissues when attacked by tuberculosis. Some tissues resist completely its invasion, as the fibrous tissue of tendons and fascia; others, when attacked never tend to repair, as tubercular ulcers of the intestine. In still others, as the peritoneum, the reparative power or resistance offered to the advancement of the disease is great.

While a large percentage of the mortuary material is furnished by tuberculosis of the lung the statistics show more than an equal number in which the tuberculosis of the lung was completely cured or circumscribed and did not contribute in any way to the death of the patient. So common are the evidences of repaired, cured tuberculosis in the lung that the Germans have an axiom that every man at the end has a little tuberculosis. In 1000 necropsies, excluding 216 cases that died of phthisis, Osler found undoubted evidence of previous tuberculosis in 59 cases, 7.5 per cent., but Bollinger, Massini and Harris placed it very much higher, ranging from 27 per cent. to 39 per cent., far exceeding those that died of tuberculosis. Bouchard, in his report of postmortems, found that in over 75 per cent. of persons dying suddenly there was some evidence of tuberculous lesions, active or obsolete. A comparison of the postmortem evidences of repair of tuberculosis in the various tissues shows that the lung far exceeds any other tissue in the body, not excepting the peritoneum, in its ability to overcome the effects of tubercular inoculation. This repair is effected by the development from fixed connective tissue cells of resisting capsules of connective tissue with sclerosis and cicatrization of the walls of the cavities. These walls resist the biotic and toxic effect of the bacillus; subsequent degeneration of the encapsulated products takes place, or there is an elimination of the infected focus with its bacilli by necrosis and exfoliation, as illustrated after the use of the Koch tuberculin injections. Investigation shows further, that the so-called "deaths from tuberculosis" are rarely due to the tuberculosis itself, but to secondary infections, that is, it is not the tuberculosis which kills but the mixed infection (pus and sapregenic) of the tubercular centers; the same is true of tuberculosis in other tissues. Do postmortem examinations show us how the encapsulation of tuberculosis is favored or accomplished? Yes, to a limited degree. Does clinical experience, surgical or medical, offer any suggestions or proofs? Yes, both furnish many if they are properly interpreted. Tuberculosis of the lung is primarily in the great majority

of cases a local disease involving but a small portion of one lobe of the lung. Ewart and Kingston Fowler described this process and showed that its extension followed well-defined routes. It advances from the original pulmonary focus by continuity, through the lymph spaces and lymphatic channels and through the blood, and rarely, if ever, along the mucous surface on which the myriads of bacilli are transmitted to the mouth. Pathology teaches us that the effect of the biotic and toxic stimulation of the bacillus is to produce lymphoid cells and a multiplication of the fixed and connective tissue cells of the part; they induce increased deposit of leucocytes and vascular changes, with subsequent necrosis and caseation of the center of the nodule. (Baumgarten.) In tissues containing epithelium these cells also proliferate and the connective tissue cells yield epitheloid and giant cells. (Gaule and Arnold.) Further, the tendency in most tissues in the body is to wall in the destructive process by the formation of a capsule. Tubercular lesions represent reaction of the tissues to the irritation of the tubercle bacillus. In the center of the foyer the irritation is sufficient to destroy the tissues; farther off the irritated tissues build a wall, which in time, makes a cicatricial barrier, plugging up lymphatics and constricting vessels. Leucocytes and wandering cells are attracted by dead bacilli. Living bacilli stimulate connective tissue alone. (Evans.) We have still further abundant proofs that this capsule is destroyed or lessened by secondary infections; that its limiting power is enhanced and favored by physiologic and anatomic quiescence. Its strength and resistance are further favored by aseptic stimulation of cell proliferation in its periphery. The study of the literature on repaired tuberculosis of the lung shows that there was an atelectasis and cicatrization of the pulmonary tissue in close proximity to the nodule; that there was a fibrous and cicatricial development often in the entire lobe which was repaired; that the pleura in the neighborhood of repair was greatly thickened, and effectually immobilized the lung contiguous to it; that the chest wall was contracted and motion of the diseased part was restric-

ted. In other words, the histology of the repair of tuberculosis of the lung in its entire range, from the solitary tubercle to a complete lobe, is made up of a series of defunctionalizing processes, anatomic and physiologic, in every tissue involved directly or indirectly.

Treatment.—Hiller, Berlin, hoped to aid the cicatrization and contraction of the lung by the injection of irritating material into the lung itself, as iodin, iodid of potassium and carbolic acid. His method was tried by Ewald, Pepper and Jablovoski; they failed to obtain good results. Lepine injected sublimate solution into pneumonic lungs and observed a rapid diminution of temperature and improvement in breathing. Contraction of the chest wall for the cure of tuberculosis by means of cauterization of the chest was practiced by Guerin and Vidal. They reported 37 good results in 44 cases. Mosler tried this treatment in 20 cases and while he found great improvement in many he does not report a single cure.[68] Rive injected iodin and iodid of potassium into the cavities with only temporary relief; he had one fatal result from cerebral embolus.

The pathology of repair of pulmonary tubercular cavities involves certain physical conditions which are peculiar to the chest (they exist to a certain degree in abscess of the bone and brain), namely, the constant resistance of the bony framework against contraction, the effort at expansion of the cavity in each inspiratory act. The best illustrations exist in large empyemic cavities. The bony framework of the chest wall admits of a certain degree of contraction of the cicatricial tissue which makes up the boundary of the empyemic cavity, and then contraction ceases and the cavity remains permanent; as shown in Fig. 20*a*. This element was overcome by the operations of Estlander, Schede, Delagéniere and their modifications, all based upon the same principle, reducing the bony resistance; all artificial means of allowing the obliteration of a cavity by cicatricial contraction and agglutination of its walls. This same resistance to nature's repair exists in every pathologic pulmonary cavity in addi-

68 Verhand. des Cong. f. Innere Med., Wies., 1883, vols. i–ii, p. 82.

tion to the ordinary abscess conditions. Allow the wall of the abscess to collapse, to empty thoroughly, and it will heal as other abscesses of the same pathologic character; this I believe is the keynote to the successful treatment of pulmonary cavities. How to overcome this resistance of the chest wall was a stimulus to my investigations in lung surgery and led to the hope that not only might pulmonary cavities be obliterated by permitting or forcing their collapse, but that primary tuberculosis might be encapsulated by mechanical immobilization of the diseased portion by collapse and enforced rest of the lung as a respiratory apparatus, thus allowing the cicatrization and encapsulation of the tubercular foci; in other words, that tuberculosis of the lung might be treated as we treat tuberculosis of the joints, by immobilizing and enforcing physiologic rest; by enforcing drainage of the secondary products through the bronchi and allowing the ulcer or cavity to heal.

Are we furnished any evidence from the record of postmortems that may be appropriated to support the principle that immobilization and physiologic rest of the lung is favorable to the healing of pulmonary tuberculosis and pulmonary cavities? Yes. 1. Lungs that have been severely involved in tuberculosis, empyema, pneumonia, gangrene or abscess when repaired show a contraction of the chest wall in proportion to the degree of tissue involved; 2. Lungs with tuberculosis that have been compressed by pleuritis exudates, usually sequences of the pulmonary tuberculosis, have repaired the primary tubercular focus during their quiescence; 3. Lungs that have been allowed to collapse following radical operations for the obliteration of empyemic cavities (tubercular in a large percentage of the cases) have healed.

That empyema is curative of tuberculosis of the lung in its early stage I believe can be readily proven. The great majority of empyemas in the adult is the result of primary pulmonary tuberculosis, 83 per cent.; in children tuberculosis is rarely the cause of empyema. In most of the post-mortems on chronic purulent tubercular pleurisy tubercular lesions of the lung or other organs are found, but these lesions are generally

quiescent and localized. Empyema from tuberculosis never absorbs and rarely opens into a bronchus. It is a result of mixed infection of the primary tubercular nodule in the lung extending to the pleura. (Strauss.) Of 164 uncomplicated cases of empyema operated by Koenig, Cabot and Runeberg, 7 remained with fistulæ and were incomplete cures, 4 died, and 9 were lost sight of before the cure was complete; all the others recovered. This shows what a favorable termination empyema may have, and considering that it is secondary to tuberculosis in a great majority of cases (83 per cent.) it speaks forcibly for its curative effect upon the lung. Whitney[69] says "the course of tubercular empyema is peculiarly benign." In 16 cases of pleuritic, non-suppurative effusion, Netter found bacilli in all. It is the prevalent opinion of pathologists that pleurisy from "cold" rarely if ever occurs. Strauss quotes from German authors that "simple" pleurisy is tubercular pleurisy, the true nature of which is not recognized; tuberculosis is the usual etiologic condition in pleurisy; one can say that it represents the real cause in over three-fourths of the cases. Landouzy regards pleurisy from cold as absolutely exceptional. Kelsch and Villard, who investigated 16 cases, say that pleurisy is only a local manifestation of tuberculosis. Chauffard and Gombault inoculated the fluid from 20 simple pleuritic exudates in guinea pigs; 10 died of tuberculosis, the negative cases do not prove that they were not tubercular. Every general practitioner recalls numerous cases of tuberculosis of the lung resulting in empyema or hydrothorax in which there was a complete recovery of the tuberculosis when the empyema and hydrothorax were operated at the proper time. In considering the curative effect of pleuritic effusions upon tuberculosis of the lung we do not include the advanced cases of tuberculosis in which one or more lobes are honeycombed with the disease; here, on account of the consolidation of the lung, it is impossible for the pleuritic effusion to produce collapse and compression of the cavities. When I began this line of investigation I had hoped to find in the reports of

[69] Twentieth Century Practice of Medicine.

the great pathologic institutes detailed accounts of the condition of the primary tubercular focus in the lung and prove my position by them; so far I been unable to find this material, as the postmortem records at my disposal have been defective in this particular. I have called the attention of a number of pathologists to this point and hope shortly to be able to submit accurate descriptions of the tubercular process in the lung with empyema. I do not believe that the empyema or the hydrothorax is advantageous to the tubercular process; by an inhibitory power exercised by the fluid or by a venous stasis, as suggested by Fowler,[70] of Brooklyn, in his able article, "Surgery of Intrathoracic Tuberculosis." On the contrary, from this standpoint it is detrimental, as it impairs the general condition of the patient. It increases the immediate danger, but favors the ultimate result. Nothnagel and Schrader do not remove the effusions primarily. The force of numbers of operated cases of empyema with permanent cure of the primary tuberculosis of the lung carries conviction that the compression of the lung favors the reparative process, and in this way the pleuritic effusion is curative. Quiescence of the lung greatly diminishes lymphatic circulation and thereby lessens materially the likelihood of the propagation of the tuberculosis to the other parts (W. A. Evans), a fact of great moment, as the tuberculosis is disseminated, from a practical standpoint, almost exclusively by the lymphatics. The methods of obtaining pulmonary quiescence or collapse are: 1. By permitting or forcing the collapse of the lung by separation of the parietal pleura and intrathoracic compression (extra-pleural pneumothorax); 2, by removing the bony resistance and allowing the collapse of the chest wall, thus favoring contraction and cicatrization (thoracoplasty); 3, allowing the lung to collapse by intrapleural injections of gas or fluid. The third method appears to offer more than any of the others. We know that atelectasis of the lung may exist for months, or even years, and the lung be again restored to its function, as shown by West's cases of six to eighteen months' compression

[70] Ann. of Surgery, 1886, xxiv, p. 591.

with effusion, which were followed by immediate restoration of the lung to full size after removing the fluid; 2, the treatment is simple and painless; 3, the patients will consent when the pathologic condition is most favorable.

Good results were obtained in tubercular cavities with thoracoplasty by a number of authors. De Cazenville and Sengler report recoveries from disease of right apex. Baier reports a temporary recovery. Stewart Tiday supplemented this operation with external compression with adhesive plaster. Coromilas and McEwan favor thoracoplasty.

I have performed the following operation for the purpose of allowing the lung to collapse over a tubercular cavity:

Case 1.—Stephen D., English, age 40, single, clerk, Cook County Infirmary, Surgical Ward 7. Family history: Tuberculosis caused death of mother, two sisters and two brothers. Has had tuberculosis for three years; is emaciated and anemic. The upper lobe of right lung is consolidated; has evidence of a large cavity extending from the first rib to the lower margin of the third with a transverse diameter of two inches; has marked cracked-pot sound; he expectorates two ounces of material with each seizure of coughing; râles over the upper portion of the right lower lobe behind and some râles over the upper lobe of the left lung; no evidence of consolidation in this lobe; tubercle bacilli present; patient had an evening temperature ranging from 102 to 102.5 degrees F. It was decided that he was not in a condition to drain the cavity, and a compression of the lung over the position of the cavity was determined upon.

Operation.—Jan. 9, 1898, chloroform narcosis. Immediately before operation the patient's temperature was 100 degrees, pulse 98, respiration 28; there was a frequent hacking cough. A U-shaped incision was made, beginning at the sternum and the second rib, extending down to the third and then three inches to the right and up again to the second rib; the skin and muscular flaps were elevated; subperiosteal resection of three inches of the second rib; the parietal pleura was detached from the chest wall for a considerable area downward and outward, so as to allow of a greater compression of the lung at that point. The flap was replaced and retained with a deep musculo-cutaneous suture. Very little chloroform was used, as the patient was somewhat cyanotic when the operation began; it was feared he might die on the table. He was placed in bed and rallied rapidly.

At 7 P.M. the day of operation pulse was 108, temperature 101, respiration 32; January 10, 8 A.M., pulse 98, temperature 99.2, respiration 30; slept five hours; cough more constant and less spasmodic with considerable expectoration. January 10, 2 P.M.,

pulse 100, temperature 99.6, respiration 27. January 10, 7 P.M., pulse 104, temperature 100.2, respiration 30. January 11, 8 A.M., pulse 102, temperature 99.2, respiration 30; slept eight hours. January 11, 8 P.M., pulse 104, temperature 100.2, respiration 52. January 12, A.M., pulse 94, temperature 99.4, respiration 32; slept nine hours. January 12, P.M., pulse 96, temperature 99.8, respiration 34. January 13, A.M., pulse 94, temperature 98.8, respiration 30. January 13, P.M., pulse 96, temperature 99, respiration 32. January 14, A.M., pulse 98, temperature 98.8, respiration 30; slept nine hours; marked improvement in cough and expectoration. January 14, P.M., pulse 100, temperature 99.4, respiration 34. January 15, A.M., pulse 88, temperature 98.8, respiration 32. January 15, P.M., pulse 90, temperature 99.4, respiration 34. January 16, A.M., pulse 84, temperature 98.6, respiration 32. January 16, P.M., pulse 86, temperature 98.4, respiration 33. January 17, A.M., pulse 88, temperature 98.4, respiration 24. January 17, P.M., pulse 90, temperature 98.4, respiration 24. January 18, A.M., pulse 84, temperature 98.4, respiration 22.

From this time on his temperature, pulse and respiration have been normal; there was primary union of the wound and great depression of the chest over the site of operation. The patient's expectoration has diminished more than half, and is of a light foamy character. His improvement was progressive. He has gained in weight and appearance. April 30 physical examination reveals an entire absence of râles and bronchial breathing on the right side; there is diminished respiratory sound over the seat of depression of the chest wall; no physical signs remain to indicate that a cavity had existed in this locality. On the left side there are râles extending down to the nipple. These physical signs were verified by Drs. George W. Johnson and W. A. Evans. The repair of the lung which has taken place can be seen in radiograph of the right lung; no cavity exists. If the lung in this case were involved to a greater degree I could have inserted my entire hand through the opening in the chest wall into the chest cavity and separated the lung from its adhesions to the wall and compressed it.

Examination July 8 shows that the tuberculosis in the right lung was entirely quiescent. There was not a râle to be heard; the cavity was obliterated; there were some râles over the upper lobe of the left lung and the upper portion of the lower lobe; the patient has had no fever and has had but little expectoration.

Dr. Alexander C. Weiner and Dr. James G. Berry examined this patient with me.

Carron proposed to compress the lung over tubercular cavities with the hope that the collapse of the lung would be followed by an obliteration of the cavities. MacEwen favors resection of the ribs to allow the contraction of the chest over small cavities and the drainage and even curettement of large ones. Coro-

milas, Greece, favors pneumotomy and early surgical interference in tubercular processes.

If the adhesions be firm and the parietal and visceral layers can not be separated, then the parietal layer should be separated from its costal attachments and allowed to sink in with the lung, or it should be held compressed by a tampon beneath the flap for forty-eight to seventy-two hours. Will found that in thirty-six cases of tuberculosis in the early stage, thirty-two admitted of complete collapse of the lung and four only partial. If on examination it be found that the lung is free from adhesions, or that circumscribed adhesions exist, then the treatment is entirely different; the lung may be forced to collapse by the injection of a fluid which is slowly absorbed, as the mineral oils, alboline, etc., or better still, it may be compressed and retained compressed by the injection of nitrogen gas, after the method described for the determination of pleuritic adhesions. That this method is practicable, as far as its technique is concerned, I have demonstrated in the following cases. It can be given with little more pain than a hypodermic injection. The patients suffering from tuberculosis of the lung on whom I used this treatment are progressing favorably. We have had no postmortems to show the reparative effect upon the tubercular process. The radiographs show distinctly that the lungs remain compressed. The X-ray is of inestimable value in studying pathologic processes of the lung, particularly in the localization of cavities (see radiographs Nos. 5, 6 and 7). The degree of compression of the lung can be photographed and the rapidity of absorption of gas estimated by comparison of pictures (see radiographs Nos. 8 and 9). The outline of adhesions when gas is injected is pictured on the plate (see right side of radiograph No. 10). The following histories illustrate the method of injection and its effect:

Case 1.—Charles K., age 23, Cook County Infirmary, was admitted to the hospital April 30. He had suffered from tuberculosis of the right apex since November, 1897. Physical signs showed that it extended down to the lower margin of the third rib; there was no evidence of a cavity; tubercle bacilli were found in the sputum; patient had been coughing

for three months; this was so frequent and persistent that he could not sleep. His temperature on the evening of his admission was 102 degrees. He had been having night sweats, was somewhat emaciated, and his appetite was poor. It was decided to immobilize the lung. One hundred and twenty cubic inches of nitrogen gas was injected in the sixth interspace after the method described above. The lung collapsed and he presented all of the signs of pneumothorax. The heart was displaced to the left five-eighths of an inch. The patient's breathing while on the table was a little rapid and the effort somewhat labored. He was up and about the room in five minutes and stated that he felt no distress whatever from the treatment. His cough was almost immediately relieved; he slept the following night without a coughing spell; during the day there was a superficial coughing effort to "clear the throat," as he expressed it. Eight days after the injection he came to my office and I examined him and found that the pneumothorax still existed. There was a small area of emphysematous crackling in the neighborhood of the puncture; distant tubular breathing could be heard; the patient's temperature had lowered to 99.7 degrees in the evening and was usually below normal in the morning. I had a radiograph of his chest made at this time. (See radiograph No. 8. Left side of plate was defective.) I have seen this patient every week since and his condition continues good. The last radiograph shows that but a very small quantity of the gas had disappeared, which I believe has escaped into the cellular tissue of the chest wall, as the area of the emphysema has increased.

Examination July 8. The pneumothorax had not diminished in the least. There was not a respiratory sound on the right half of the chest. The hepatic dulness was down almost to the margin of the ribs; the intercostal spaces bulged; there was a tympanitic percussion note over the right half of the thorax; the pulmonary quiescence was still complete. The patient had not coughed or expectorated a particle in five weeks; eats and sleeps well. He had had no fever and his temperature at 4:30 today is 98.2 degrees. He had not been weighed, although he feels that he has gained in weight. It is two months and a half since the injection was made and the quantity of gas is practically the same, showing that the absorption of the nitrogen is extremely slow indeed, if any of it is removed by that process.

Dr. Alexander C. Weiner and Dr. James G. Berry examined this patient with me.

Case 2.—E. L., male, age 34, Cook County Infirmary, was in the second stage of phthisis, with cavity in right upper lobe. Endeavor was made to fill the right pleural cavity with gas, but as adhesions were found it could not be accomplished. He was not in condition to withstand operation for compression of the chest wall. The gas entered the cellular tissue of the chest and remained there three weeks, showing how slowly it is absorbed.

Case 3.—H. A. E., male, age 30, Alexian Brothers' Hospital, admitted May 10, 1898. Family history shows several cases of

tuberculosis. His cough and fever began about Oct. 1, 1897. Cough very severe, expectoration limited. Night sweats since January, 1898. There were physical signs of apical tuberculosis on the right side; patient gave no history of pre-existing pleurisy; he was placed on the table, trocar inserted in the sixth intercostal space, anterior axillary line and two hundred cubic inches of nitrogen gas was injected after method described above. It was found when the trocar entered the pleura that it required no pressure to force the gas into the pleural cavity. It produced very slight coughing and but little anxiety to the patient from shortness of breath; the pulse was increased in frequency to 96 and the lips were discolored a light blue; the apex beat was displaced one inch to the left, the hepatic dulness three inches downward; the respiratory sounds entirely disappeared on the right side; respirations were increased to 26. Patient was removed to his bed; thirty minutes later was sitting up in bed eating his dinner; he said "he felt a binding in the chest and a tickling sensation in the throat;" he remained in bed for two days, as his respirations were a little increased in frequency and he complained of some discomfort in the epi-sternal region. Radiograph No. 11 shows the compression of the right lung. Examined May 20. The respiratory sounds still absent; the cardiac displacement continues; there is still absence of the hepatic chest dulness; his respirations are normal and his cough has disappeared; no expectoration.

June 30 patient presented himself again for examination; he thought his breathing was still a little short. Cough has entirely ceased; he has had no night sweats; has gained ten and one-half pounds in three weeks; his appetite is excellent.

Physical examination: The respiratory sounds are returning, though still distant; there are no râles; the percussion note shows that the chest has still a considerable quantity of gas, the liver dulness is absent down to the margin of the eighth rib and the apex beat is in about the normal position. The mediastinal dulness is to the left of the margin of the sternum; there is some bulging of the intercostal spaces, though not so marked as in previous examinations.

Case 4.—P. C., male, age 23. Admitted to Alexian Brothers' Hospital six weeks ago. Patient was in second stage of tuberculosis of the right lung. May 12 an effort was made to inject the gas in the usual manner, but adhesions prevented the admission of the gas.

Case 5.—Alexian Brothers' Hospital, E. D., May 12. Patient in first stage of tuberculosis in the right apex; has had cough, expectoration, night sweats and fever since August, 1897; bacilli in the sputum; had frequent attacks of pleurisy. Method of injection of gas the same as in case 1. Puncture made in sixth intercostal space, mid-axillary line. When parietal pleura was penetrated the gas readily passed into pleural cavity; seventy cubic inches were injected. Physical signs of pneumothorax rapidly appeared; liver dulness displaced downward one and one-half inches; apex beat displaced one-half inch to the left. Patient said he felt "his breath was shorter." The opening was sealed. In one-half hour the patient said he

felt no inconvenience whatever from the injection, and was walking about the ward. He left the hospital a few days following his injection on May 12. I did not see him again until he presented himself for examination June 30. He was greatly improved in appearance; there was a slight cough, but no expectoration; he had gained in weight; his appetite was excellent.

Physical examination showed that there had been some absorption of gas, although a tympanitic sound was distinctly present over the former area of liver dulness. The respiratory sounds were feeble; there were no râles. Seventy cubic inches of gas was injected in the usual manner. It did not produce the slightest discomfort. After the injection the liver dulness was displaced almost to the costal arch. There was no displacement of the heart. There was some bulging of the intercostal spaces. Patient left the hospital immediately for his home.

July 7, at Alexian Brothers' Hospital two cases of apical tuberculosis were injected; in one 75 and in the other 80 cubic inches of gas was used; in neither was there the least discomfort from the insertion of gas; in a third case adhesions were found, making it impossible to succeed in the injection. The cases in which I believe this method most practicable are apical or monolobar tuberculosis in the early stage, as the pathologic conditions are such that the compression of the lung can be accomplished and adhesions are not likely to be found. I do not consider that it is indicated nor practical in advanced nor chronic tuberculosis, as the fibrous tissue deposited in the lung will not permit compression of the lung, nor will the pleuritic adhesions allow of gas injection. So far no conclusion can be drawn as to the ultimate result of this treatment. Theoretically its dangers may be: *a*, hemorrhage from wounding the intercostal vessels; *b*, injecting gas into the intercostal vein, the possibility of which I question; *c*, infection by the use of impure gas, infected trocar or improper antiseptic preparation of chest; *d*, rupture of infected foci into the pleural cavity through compression of lung and separation of pleuritic adhesions; *e*, dyspnea from the use of too large quantity of gas; this can be readily relieved by changing the direction of the current in the siphon; *f*, puncture of the lung with the canula. This will not take place unless adhesions are present, and if the lung should

be punctured it is a matter of no consequence, as experiments and clinical experience show that the lung can suffer great traumatism without danger. While these possibilities of danger are mentioned, none of them occurred in my experiments. I believe the gas should be reinjected every six to ten weeks as might be deemed necessary in the individual case depending upon the amount of absorption. If the respiratory sounds return the injection should be repeated. So far I have repeated the injection in but one case.

Technic of injection.—The point of insertion of the trocar varies somewhat in the individual case. If the apex of the lung be the seat of the lesion, the trocar should be inserted below the fourth interspace and back of the mid-axillary line. The best point is in the fifth interspace at the anterior axillary line. If it be a middle or lower lobed tuberculosis, the injection should be made over the upper lobe, preferably in the third interspace just outside the mammary line The chest wall should be thoroughly cleansed and rendered aseptic. Chlorid of ethyl should be used for local anesthesia. A tenotome puncture should be made through the derma; this allows the trocar to be easily inserted. The stilette in the trocar should be withdrawn when the rib is reached; the gas should now be turned on; the trocar should then be pushed inward, hugging the margin of the rib. When the parietal pleura is punctured the trocar advances rapidly and the gas begins to flow freely into the cavity unless adhesions exist. If adhesions be present the gas will not flow. The trocar should be taken out and inserted in the same manner in another position.

The quantity of gas to be injected will vary considerably and should range from 50 to 200 cu. in.; the amount to be given in each case will be regulated by the symptoms—distress, dyspnea and the displacement of the mediastinal contents and diaphragm. The respiratory sounds on that side should be suppressed unless too great dyspnea is produced. If the patient's discomfort is great the current of gas can be reversed until relief is obtained. The trocar should then be withdrawn, the wound sealed with collodion and a

moderately firm cotton compress placed over the puncture. The compress is to prevent the escape of gas from the pleura into the subcutaneous cellular tissue. The lung should be kept quiescent from three to six months or even longer, depending upon the symptoms. When the lung re-expands, if there be evidence of active tuberculosis, the injection should be repeated; also when the respiratory sounds return the injection should be repeated, that is, the quiescence must be maintained to have the treatment effectual. During the treatment the hygienic surroundings of the patient should be the most favorable; his diet should be wholesome and nutritious.

Preparation of the nitrogen gas.—The nitrogen gas used on my patients was prepared by Prof. John A. Wesener of the Columbus Medical Laboratory, in the following manner: Compressed air was allowed to pass slowly through a solution containing pyrogallic acid and potash; this solution absorbed the oxygen, the nitrogen thus obtained was purified by washing it through potash and then through sulphuric acid; it was then collected in a rubber gas bag which had been sterilized with a 5 per cent. carbolic acid solution. It may be retained in the gas bag or stored in a small metallic cylinder.

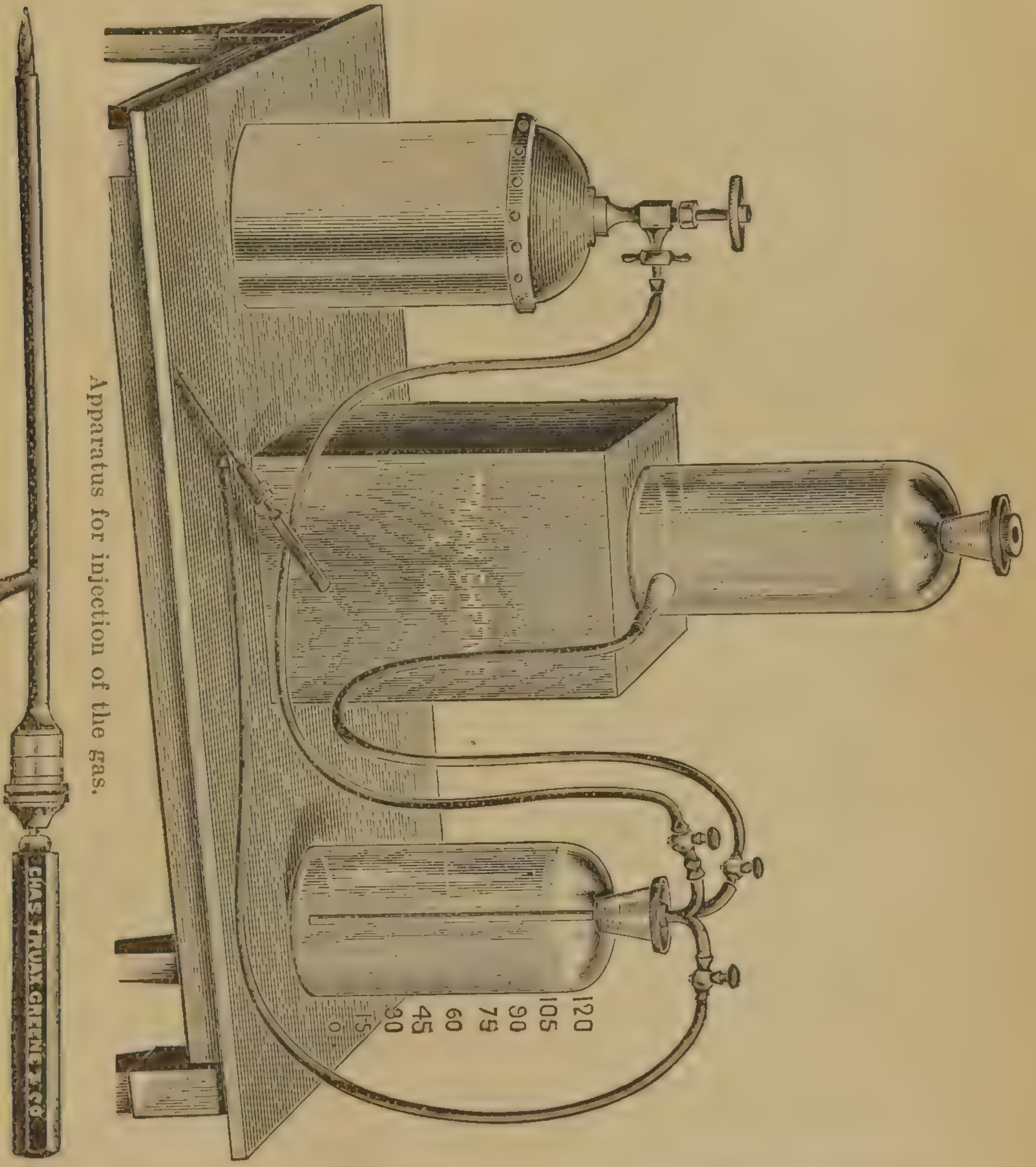
APPARATUS.

A properly constructed apparatus should provide means for noting the escaping gas and measuring its volume in cubic inches. The appliance shown in the accompanying illustration consists of a gas bag for storing the gas, a graduated bottle in which the passing gas may be measured, and a reservoir for securing hydrostatic pressure by means of which the gas may be forced into the pleural cavity.

The measuring bottle is supplied with a three-way stop-cock, one to connect with the gas bag, one with the reservoir, and a third with the trocar. One of these stop-cocks terminates in a tube extending to the bottom of the bottle, this cock being connected with the reservoir. It will thus be seen that if the measuring bottle be filled with water and the reservoir bottle be placed slightly above it, the water may be forced into the latter by slight pressure on the nitrogen bag. After replacing the water with the gas, the former may be used as hydrostatic pressure to force the gas into the cavity.

The trocar selected is of the Emmett type, one that may be attached to the bottle before its introduction. It consists of a straight canula to which is joined at a point near its proximal end a side tube, with which the connection is made with the

bottle. This tube forms a bifurcation in the lumen of the main canula. A suitable packing is closely pressed around the trocar shaft, so that when the perforator is withdrawn the point will rest within the chamber at its proximal end, forming an air-tight joint. The one I prefer is No. 7, French scale.



Apparatus for injection of the gas.

Trocar—No. 7, French scale.

Directions.—Fill the graduated bottle with sterilized water and close it with the three-way stop-cock, securely fastening the latter in place and closing all the cocks.

Place the reservoir or douche bottle on a box or shelf at such a height that the bottom of it will be on a level with the three-way cock in the graduated bottle. This height may be varied

according to the pressure desired. Connect this bottle with that branch of the three-way cock that terminates in the rubber tube leading to the bottom of the graduated bottle.

Fill the gas bag with nitrogen gas and connect it with one of the other stop-cocks. Attach the trocar to the longest of the three pieces of rubber tubing and connect it with the remaining stop-cock. Open the two stop-cocks leading to the upper bottle and gas bag. Slight pressure on the latter will force the gas into the graduated bottle and the water from the latter into the reservoir. Continue this pressure until the gas fills the bottle down to the zero mark. Close the stop-cock leading to the gas bag and open the stop-cock leading to the trocar until a small quantity of gas has escaped, thus displacing the air within the tube. Close the stop-cock and introduce the trocar, after which open the stop-cock permitting the gas to pass through the trocar. The water pressure in the reservoir, if the trocar be properly introduced, should force the gas into the pleural cavity, the water gradually replacing the escaping gas. By watching the graduated scale the amount of gas indicated may be accurately noted.

Incision and drainage of tubercular cavities.—Phthisical cavities have been recognized for centuries. Two very interesting accidental drainages of tubercular cavities are referred to by many writers on diseases of the lungs. One is the case of Pheracus, who was suffering with disease of the lung, and believing he was beyond cure placed himself in the front of battle and received a spear thrust which opened his pulmonary cavity and restored his health. Another was a case by De Bligny, 1679: the son of M. de la Genevraye, who was suffering from phthisis, received in a duel a sword wound in the right side between the fourth and fifth ribs; there was an abundant purulent evacuation from the wound; after the accident he completely recovered. In both of these cases, which appear mythical though true, there is nothing definite known of the nature of the abscesses, Paget has placed them as tubercular. The operation for drainage of tubercular cavities received its greatest impetus shortly after the introduction of the Koch lymph, 1890, when it was considered desirable to drain the cavity to favor the exfoliation and elimination of the sequestrum supposed to be produced by the Koch lymph. Cases in extremis, as far as the tuberculosis was concerned, were operated at that time; but the operation has gradually fallen into disuse so that it is resorted to now only in particularly favorable cases. Eward, 1884,

considered the drainage of tubercular cavities curative as well as palliative, but cited no cases. The greatest barrier to surgical treatment is the difficulty of diagnosis and localization of the cavity. Physical signs, as auscultation and percussion, usually indicate the cavity at a greater distance from the hilum than it really is; this is particularly true of cavities in the lower lobe. The radiograph is of great assistance in determining the location of the cavity, as can be seen in those herewith reproduced; accurate pictures should be taken before every operation. (See Radiographs v, vi, vii.) The cavity having been located and if the drainage is all that is intended a small portion of the rib may be removed over the site of the cavity and the cavity opened; this I do not consider the best practice; four to six inches of at least three ribs in the neighborhood should be removed to allow collapse of the chest wall as cicatrization and contraction of the cavity take place after drainage. The parietal pleura should be separated from the ribs before incising it. Palpation of the area aids materially in the location of the cavity; digital exploration after incision of the lung should be favored in tuberculosis. As early as September, 1873, Mosler incised the pleura and worked his way through the lung to a cavity by dilating the tissue with an artery forceps. The patient improved very much after the operation; subsequently he died of Bright's disease.[73] When the location of the cavity has been determined incision should be made with the scalpel: small cavities will probably be opened before the large one is reached; the lung can be gently retracted until the large cavity is freely incised; the hemorrhage may be controlled with a catgut suture or the surface seared with the Paquelin cautery. The cautery should not be used to divide the lung, as it prevents inspection of the divided tissues and makes it uncertain when the cavity is reached. The entire cavity should be packed with iodoform gauze, which should be allowed to remain for several days. A drainage tube may then be inserted or the gauze packing repeated. Failure to find the cavity has frequently occurred. The ultimate result of drainage of tuber-

73 Berliner Klin. Woch., 1873, xliii, p. 509.

cular cavities has been very unsatisfactory, which might be expected from a knowledge of the pathology of the diseased stage of cavern formation. The cavities are often multiple and only one is drained by the operation, and the tuberculosis continues its usual course in the other portions of the lung. The rapidity of amyloid degeneration of other organs may be somewhat retarded by the drainage; in a number of cases pulmonary fistulæ remain. In 1890 I saw Hahn do a number of these operations and subsequently use the Koch lymph; at that time he reported that from his observations the results would not be satisfactory. Sonnenberg, in 1891, reported good results from this treatment. Kecke opposed the operation and quoted six cases of tuberculosis operated by Cerenville[74] with five deaths. His personal cases were anything but satisfactory. Jaenfert[75] named certain conditions contraindicating operations on tubercular cavities: 1, tendency to hemorrhage; 2, the danger of pneumothorax; 3, drainage does not remove the original disease, and operations under these conditions give a great mortality. Truc reports 18 cases with 6 deaths within three months after the operation. Poissier and Jannesco collected 29 cases and showed 10 deaths, 15 improvements and only 4 recoveries. Hofmokl reports 5 cures after treatment of tubercular cavities by operation. Douglas Powell opposes the drainage of tubercular cavities on the grounds: 1, that the cavities are fairly well drained, situated as they are in the apex; 2, the cavities are not often single with an activity of symptoms; 3, that excavation in phthisis is a conservative process. The latter statement is misleading; true, the excavation is a conservative process, but the absorption of the products of mixed infection subsequently retained in the cavity is distinctly injurious to the entire organism; this is the principal reason for the drainage of the cavity. Patients rarely ever die from simple tuberculosis of any part of the body, and particularly from simple tuberculosis of the lung, it is the mixed infection which causes the great fatality. Tubercular cavities

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74 Muench. Med. Woch., 1891, xxxviii, p. 399.
75 Muench. Med. Woch., 1891, xxxviii, p. 6.

TUBERCULAR CAVITIES—1878 TO 1898.

No.	Bibliography.	Sex, Age.	Nature of Disease.	Duration	Etiology.	Location.	Signs of Cavity.	Pleural Adhesions.	Puncture.	Incision.	Results. Immediate.	Results. Final.	Necropsy.
1878													
1	Williams, B., Med. J. R., 1878, Vol. 101	M. 28 yrs.	Pulmonary tuberculosis, many cavities, 6 mos.	6 mos.	Fever, much expectoration, vomiting fetid sputum.	Left side, predominating at base.	Signs of cavity.	No adhesions.	Puncture in the 7th interspace, pneumothorax and subcutaneous emphysema, 2 pints of fetid pus, lavage.	. . . . .	Considerable amelioration 6 mos. later.	. . . . .	. . . . .
1879													
2	Sadler, Lancet, 1879, Vol. 1, p. 84.	M. 38 yrs.	Tubercular cavity.	4 yrs.	Fever cachexia.	Left base.	Signs of cavity.	Adhesions.	. . . . .	Incision in 10th interspace without resection of rib opening of a small cavity with the finger. Drainage.	Death 14th day.	. . . . .	Large cavity in left base not opened.
1882													
3	Sommerfetd, Hosp. Studende, 1882, No. 17, p. 257.	M. 31 yrs,	Progressive phthisis.	. . . .	. . . . .	. . . . .	Large cavity in right upper lobe.	. . . . .	. . . . .	Puncture of cavity with trochar coarse, drainage.	No influence on general condition.	Death in 28 days after operation.	. . . . .
1882													
4	Bull. M. World Med. Archives, 1882, Vol. 1, No. 26.	M. 29 yrs.	Circumscribed pneumothorax with underline tubercular cavity.	. . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	Thorocotomy and with forceps bored into lung, cavity was reached.	Patient died 7 days after operation.	. . . . .	. . . . .
1883													
5	Bull. Centr. F. Chirurgie, 1883, p. 104	M. 29 yrs.	Tuberculosis of left apex. 3d stage.	. . . .	Cough, expectoration, hectic fever.	In 1st and 2d intercostal space anteriorly.	Signs of cavity.	Adhesions.	Puncture made, blood.	Pneumotomy.	Death on 6th day.	. . . . .	Partial pneumothorax, a large superficial cavity in left lung.
1884													
6	Spencer Wells, Brit. Med. Jour., 1884, Vol. 1, p. 1117.	M.	Tubercular cavity with axillary abscess.	. . . .	Axillary abscess with signs of cavity of right apex.	Right apex.	Signs of cavity,	. . . . .	. . . . .	Incision of axillary abscess, issue of pus and gas. The liquid discharged is similar to the expectorate of the patient.	Recovery.	Recovery without fistula.	. . . . .
1885													
7	De Trerville, Revue Medicale de la Suisse Romande, 1885, p. 463, Obs. 4.	F. 15 yrs.	Advanced tuberculosis of both apices.	2 or 3 years.	Hectic fever.	Left apex, clavicle to 4th rib.	Signs of cavity.	Adhesions.	. . . . .	Resection of 8 cm. of 2d left rib, exploratory puncture, removal of purulent and bloody fluid. Pneumotomy, opening of cavity.	Recovery. Observation 15 days after recovery.	. . . . .	. . . . .
1885													
8	Frainkel in Truc thèse de Lyon, 1885, p. 78.	M.	Advanced pulmonary tuberculosis.	. . . .	Hectic fever.	Apex 2d intercostal space.	Signs of cavity.	. . . . .	. . . . .	Pneumotomy, drainage, insufflation, iodin and phenol.	Death, Hemoptysis.	. . . . .	Purulent cavity with granulatous wall.
1885													
9	Truc th. de Lyon, 1885, p. 79 .	M. 38 yrs.	Pulmonary tuberculosis.	. . . .	Sudden and severe pains under the right clavicle.	Right apex anteriorly.	. . . . .	Adhesions.	. . . . .	Pneumotomy, discharge of pus, air and gangrenous debris, drainage.	Death 15th day. Pains increased after operation.	. . . . .	Bilateral tuberculosis, cavity opened.
1885													
10	De Cereville, Rev. Med. de la Suisse Romande, 1885, p. 463, Obs. 3.	F. 40 yrs.	Pulmonary tuberculosis. 3d period.	. . . .	Hectic fever, cachexia.	Left base.	Signs of cavity.	. . . . .	. . . . .	Thorocoplasty, resection of 5th rib to obliterate cavity which was not opened	Death 14 days later.	. . . . .	No necropsy.
1887													
11	Breen, proc. of Phil. Co. Med. Soc. 1887, Vol. 8, p. 203.	M. 27 yrs.	Tuberculosis with cavity.	. . . .	Cough, expectorated much sputa and pus. T. B. C. present, a septic temperature.	Lower left pulmonary lobe.	Signs of cavity.	Pleural adhesions.	Negative puncture. Incision, trocar introduced into cavity.	Resection of 1 and 1½ in. of 9th rib just within a line drawn from angle of scapula, small drainage introduced, next day 1 oz. of pus escaped, opening dilated and several oz. of pus escaped.	Recovery.	Steady improvement since operation.	Temperature normal.
1887													
12	De Cerruville, Archive Gen. de Med., 1887, Vol. 20, p. 477.	F. 40 yrs.	Abdominal phthisis with large cavity.	. . . .	. . . . .	Left summit.	. . . . .	. . . . .	. . . . .	Resection of 3d rib.	Death 15 days after.	. . . . .	. . . . .
13	De Cerruville, Obs. 5	F. 25 yrs.	Tubercular infiltration of left upper lobe.	4 yrs.	. . . . .	Left apex.	Signs of cavity.	Adhesions.	. . . . .	Resection of 3 cm. of 2d and 3d ribs. Pneumotomy opening of a cavity situated behind the clavicle,	Death 45th day.	. . . . .	Acute general miliary tuberculosis.
1887													
14	Sezary et vicent Revue de Medicine, 1887, p. 675.	M. 48 yrs.	Pulmonary cavity, probably tubercular.	. . . .	Pleuro-pneumonia. Hemoptysis.	Right base posteriorly.	Signs of cavity.	Pleural adhesions.	Exploratory puncture, positive.	Resection of 2 cm. of 9th rib. Pneumotomy, a cavity the size of an orange, opened and drained.	Death 7th day.	. . . . .	Single cavity opened, tuberculosis of right apex more recent, tubercles in left lung.
1890													
15	Denison, I., period. of Am. Med. Ass'n, 1890, in Centralblatt f. Chir., 1890, p. 791.	M. 26 yrs.	Pulmonary tuberculosis.	. . . .	. . . . .	Base.	. . . . .	. . . . .	. . . . .	Resection of 6th and 7th ribs. Pneumotomy, injection of vaselin and salol.	Recovery, amelioration 4 months later.	. . . . .	. . . . .
1890													
16	Tillman's. Brit. Med. Jour., 1890, Vol. 1, p. 1363.	M. 28 yrs.	Tuberculosis of left lung especially empyemia in lower two-thirds of left lung, several fistuli in left chest wall, heart displaced to right side, right lung comparatively healthy left sided empyemia began Oct. 15, 1885.	. . . .	. . . . .	Left side.	. . . . .	Left pleural firmly adherent in upper one-third.	Puncture 1 month after onset of empyemia.	Thorocotomy Sept., 1886, and Jan., 1888. with resection of piece of rib in lower and hind part of thorax. In April, 1888, extensive rib resection from 2d to 6th rib on left side in front, and 7th to 9th rib, left side behind. On May 27, 1888, front of chest wall resected from 2d to 6th rib, close to the sternal border. Breadth of resection 5 cm. above and 12 cm. below, left pleura tuberculous and right lung phthisical, large as man's fist, firmly adherent at 1st rib, left lung partly covered by pedunculated skin flap.	Organs shrank after last operation and tuberculosis of lung underwent process of spontaneous cure as a result of shrinkage.	Patient discharged as cured July 23, 1888.	. . . . .
1890													
17	Spengler, Verhand de geselsch d Naturforschen Aeuztzubremen, 1890, Vol. 1, p. 237, in Quincke, loc. cit. obs. 2, p. 241.	F. No age.	Bilateral pulmonary tuberculosis.	Several years.	Cavity of left apex, partial pyo-pneumothorax.	Left apex.	Signs of cavity.	No adhesions.	. . . . .	Thorocoplasty, cavity not opened.	Recovery.	Cured 7 mos., disappearance of signs of cavity of left apex, the right apex not operated upon, healed equally well.	. . . . .
1891													
18	Caselli baceoglitose medic., 1891, T. 11, 5th series, p. 235.	M. 31 yrs.	Tubercular broncho pneumonia cavity of right apex.	. . . .	. . . . .	Second intercostal space anteriorly.	Signs of cavity.	Adhesions.	. . . . .	Resection of 8 cm. of the 2d left rib. Exploratory puncture, removal purulent and bloody fluid. Pneumotomy, opening of cavity.	Recovery 15 days after operation.	. . . . .	. . . . .
1891													
19	Krecke, Mun. Med. Woch., Vol. 38, p. 400, 1891.	33 yrs.	Tuberculous cavity.	. . . .	Septic fever chills.	Right lower lobe.	Signs of cavity.	Pleural adhesions present.	. . . . .	Resection of ribs. Pleura opened with blunt instrument, lung over cavity was punctured, free opening made, cavity packed with iodoform gauze.	Fever fell after operation, considerable secretion, improvement after operation so patient could leave bed, sudden hemoptysis set in and caused death,	. . . . .	. . . . .
1891													
20	Kurz, Wiener Med. Presse, 1891, p. 1389.	M. 30 yrs.	Tuberculosis of lungs, large cavities.	. . . .	Expectoration, fever, cachexia.	Left apex, anteriorly.	Signs of cavity.	No adhesions.	. . . . .	Incision in the 2d intercostal space, pneumothorax. Pneumotomy, injection of iodoform.	Pneumothorax absorbed in 6 days, recovery without fistula, cavity measured 12 p. m. in diameter.	Death 3 years later, general tuberculosis.	. . . . .
1891													
21	Krecke, Munchen Med. Wochensche, 1891, p. 399.	M. 57 yrs.	. . . . .	. . . .	. . . . .	Right base.	Signs of cavity.	. . . . .	. . . . .	Rib resection. Pneumotomy, iodoform tamponade.	Death. Hemoptysis.	. . . . .	. . . . .
1891													
22	Hahun, 20th Cong. of German Society of Surgeons.	F. 22 yrs.	Cavity of left apex size of an apple.	. . . .	Purulent and fetid expectoration.	Apex anteriorly.	Signs of cavity.	. . . . .	. . . . .	Incision at level of upper border at 3d rib. Pneumotomy without rib resection, amelioration. Injections of Koch's tuberculin.	. . . . .	. . . . .	. . . . .
23	Lesser, Muncli. Woch., Feb. 24, 1891.	F. 43 yrs.	Tuberculosis with cavity at left apex symptoms had existed 4 years.	4 yrs.	. . . . .	Left apex.	Signs of cavity.	Pleural adhesions.	. . . . .	Incision in 1st interspace 7 cm. long, trocar introduced, cautery used to penetrate lung cavity size of apple, walls curetted and packed with antiseptic gauze, Koch's tuberculin injected and caused increased discharge,	. . . . .	Patient was much improved in general health, cavity dwindled down to 1½ its normal size.	. . . . .
1891													
24	Lesser.	Same as 23	except cavity was smaller.										

No.	Bibliography.	Sex. Age.	Nature of Disease.	Duration.	Etiology.	Location.	Signs of Cavity.	Pleural Adhesions.	Puncture.	Incision.	Results. Immediate.	Results. Final.	Necropsy.
1891 25	Sonnenburg, 21st Congress of German Surg. Soc., April, 1891, and in Quincke and trenzgelhet, 1896, Vol. 1, p. 240, Obs. 4.	M. 56 yrs.	Bilateral pulmonary tuberculosis more marked upon right side, lesions far advanced in right lung, less so in left, numerous bacilli.	....	.....	Right apex anteriorly.	Signs of cavity.	Adhesions.	.....	Incision parallel with clavicle, resection of a fragment of 1st rib, exploratory puncture. Pneumotomy, opening of a cavity the size of hazel nut, iodoform tamponade.	Recovery. Cavity rapidly obliterated (2 mos.) Injection of Koch's tuberculin after the operation many bacilli in the sputum.	Recovery.	.....
1891 26	Sonnenburg, Quincke, loc. cit., Obs. 5.	M. 43 yrs.	Tuberculosis of both apices, predominating in left. Two lesions in right.	....	Emaciation and fever.	Left apex anteriorly	Signs of cavity.	Adhesions.	.....	Parallel with clavicle, puncture. Pneumotomy, opening of a cavity the size of a walnut.	Recovery. Injection of Koch's tuberculin after operation.	No amelioration.	.....
1891 27	Sonnenburg, loc. cit., Obs. 6.	M. 44 yrs.	Tuberculosis of both apices, predominating in left.	21 mos.	.....	Left apex anteriorly.	In left apex only.	Adhesions.	.....	Parallel with clavicle, puncture. Pneumotomy opening of a cavity the size of a hazel nut, 1 cm. deep.	Recovery. Injection of tuberculin after operation.	No amelioration.	.....
1891 28	Sonnenburg, loc. cit., Obs. 7.	M. 35 yrs.	Bilateral pulmonary tuberculosis, predominating in right lung.	18 mos.	.....	Right apex anteriorly.	Signs of cavity.	No adhesions.	.....	Resection of 4th rib. Incision of pleura, Partial pneumothorax. Pneumotomy injection of tuberculin.	Death 7th week. Cavity opened spontaneously on 11th day through scar.	.....	.....
1892 29	Roux, Revue Med. de la Suisse romande, 1892, p. 567.	.....	Tubercular cavity located posteriorly under the scapula and inaccessible from behind.	....	.....	Right lung under scapula.	Signs of cavity.	No adhesions.	.....	Pneumotomy after suture of pleura. Opening of a small cavity. Drainage, incision made in anterior wall of thorax.	Recovery. A large cavity which could not be opened, discharged into the inside cavity 3 weeks later. Patient much improved.	.....	.....
1892 30	Roux, ibid., 1892, p. 567.	F.	Large tubercular cavity.	....	.....	Right base.	.....	Adhesions.	.....	Pneumotomy drainage.	Recovery.	Marked improvement, drainage maintained until complete closure of cavity.	.....
1893 31	Lowson, Brit. Med. J. In N. Y. Rec., April 15, 1893, Vol. 43, p. 668. Brit, Med. J. June 3, 1893.	F. 34 yrs.	Tuberculosis of right apex.	....	Dyspepsia, night sweats. Pain over top of right lung to back, cough.	Apex of right lung.	.....	Pleural adhesions.	.....	Anterior ⅓ of 2d and 3d ribs, removed parietal layer of pleura opened, apex of lung pulled out after transfixed with needle, tied with strong silk and removed.	Pneumothorax developed suddenly but gave no trouble.	Wound was healed by end of 3d week.	.....
1893 32	Shurly, J. of M. M. Ass'n, 1893, 21, p. 297, Obs, 1.	M. 48 yrs.	Tuberculosis of both apices. Hepatization in left, cavities in right. Duration several years.	Several years.	Fever, emaciation, abundant expectoration.	Right apex.	Signs of cavity.	Pleural adhesions.	.....	Level of 2d intercostal space. Pneumotomy, opening of a cavity located 2 cm. deep. Hemorrhage at the moment of incision, drainage. injection of chlorin gas next day.	Death on 8th day from hemorrhage.	.....	No necropsy.
1893 33	Shurly, ibid., 1893, 21, p. 297, Obs. 2.	M. 27 yrs.	Bilateral pulmonary tuberculosis, 3d period, cavity in left lung.	....	.....	.....	Hectic fever, multiple cavities, one large cavity in the left lung and disseminated.	Adhesions.	.....	Incision in 3d interspace. Pneumotomy, opening of a cavity, drainage. Injection of chlorin gas.	Death 24th day, cachexia.	.....	No necropsy.
1893 34	Voge, Med. and Surg. Rep. Phila., Dec. 31, 1893.	F. 28 yrs.	Pulmonary tuberculosis.	....	Superficial abscess beneath scapula.	Base posteriorly.	.....	.....	.....	Superficial incision, issue of pus, of gangrenous debris and gas. Iodin injected into the wound appeared in the sputum.	Recovery.	.....	.....
1894 35	Dandridge, D. P., Ann. of Surg., Vol. 19, 1894, p. 129.	M. 29 yrs.	Tuberculosis of lungs.	....	.....	Right lower lobe.	No posterior signs.	Pleural adhesions.	Positive puncture, bloody fluid.	3 inches of 8th and 9th ribs removed in axillary line underlying cavity freely opened, ½ pint bloody purulent fluid. caseous material evacuated, irrigations with boric and sal, skin incision partly closed, double drainage tube. tube taken out after several days. Incision healed.	Immediate improvement.	Was soon up and about house. Area of dulness diminished. Respiratory sounds heard at a lower level than before.	.....
1894 36	Parrier, Soc. de Chirurgie, 1894, p. 630.	.....	Abscess of thoracic wall communicating with lung cavities in a tubercular subject.	....	.....	.....	.....	.....	.....	Incision and drainage.	Recovery.	.....	.....
37	Truc th. de Lyon.	M. 47 yrs.	Pulmonary tuberculosis and fistulous tract opening, 4 fingers' breadth outside of nipple.	2 yrs.	Suppurating fistula.	Right apex.	.....	.....	Puncture and dilatation of tract, drainage of ½ liter pus.	.....	Recovery.	Condition satisfactory 6½ mos, later, tuberculosis still exists.	.....
1895 38	Doyen, Cong. de Chirurgie, 1895, p. 105.	.....	Pulmonary tuberculosis, 3d stage.	....	.....	.....	Signs of cavity.	.....	.....	Pneumectomy, resection of the 3d rib.	Death occurring the night following the operation.	.....	.....
1895 39	Michaux, Congres Francais de chirurgie, 1895, p. 94.	F. 26 yrs.	Tuberculosis of right lung, multiple foci.	....	.....	Right base behind.	Signs of cavity.	.....	.....	Resection of 10 cm. of 7th and 8th ribs, exploratory pneumotomy, upon opening a series of dilated bronchi were found.	Death in one month.	.....	Tuber. right apex without caviti's, small cavity at base not opened.
1895 40	Michaux, Congres Francais de Chirurgie, 1895, p. 94.	F. 28 yrs.	Tubercular cavities.	....	Profuse expectoration.	Right base behind.	Signs of cavity.	.....	.....	Resection of 7.8 cm. of 8th and 9th ribs. Pneumotomy, incision 4 to 5 cm. in depth without opening cavity.	Temporary amelioration.	Death 3 months later.	Disseminated tuberculosis in entire right lung.
1895 41	Salmoni, Clinicea Chirurgiea Milano, 1895, p. 65.	M. 34 yrs.	Pulmonary tuberculosis following upon an old pleurisy.	....	Cough, expectoration, hectic fever, retraction of thorax.	Left base.	No signs of cavity.	Pleural adhesions.	.....	Thorocoplasty, 5th, 6th, 7th, 8th and 9th ribs resected. Pneumotomy.	Recovery.	Much improved 3 months later.	.....
1895 42	Tuffier, L'Abeille, Med. Par., Oct. 28, 1895.	M. 20 yrs.	Tuberculosis of apex of right lung.	....	Tubercle bacilli found in sputum.	.....	.....	.....	.....	Incision in 2d interspace and ant. axilla pleural pneumo chorax by attaching parietal to viscera pleura. Piece of lung 2 cm. in all directions was excised, wound closed without drainage.	Patient up 9th day.	4 yrs. after operation patient was healthy.	.....
1896 43	Quincke, Mittheilunger, A. D. Greuzge bieten der med. in Chir., 1896, 1, p. 240.	M. 46 yrs.	Tubercular infiltration of right lung.	2 yrs.	Hectic fever.	Right apex anteriorly.	Signs of cavity.	No adhesions.	.....	Incision and application of a paste of chlorid of zinc in the first intercostal space. Pneumotomy after exploratory puncture, resection of 2d rib 16 days later, many small cavities opened.	Recovery,	Death 3 yrs. later from progress of the tuberculosis.	.....
1896 44	incke, Mittheil Bier in Qugeliche, 1896, 1, a. d. Greuz	M. 26 yrs.	Cavity of the right apex.	....	Frequent hemoptysis, retraction of thorax.	Right apex.	Signs of cavity.	Adhesions.	.....	Thorocoplasty, resection of 2d and 3d rlbs without opening.	Recovery.	See foot note.	Cicatrized cavity right apex, sclerotic lung cavity open'd during 2d operation is recent. Sclerosis of left apex. Enorm's sterno-costal cold abscess, communicating with the cavity opened by a narrow orifice. Right lung almost completely destroyed. left lung studded with tubercles.
1896 45	Maffert, Brit. Med. Jour., 1896, p. 392.	M. 19 yrs.	Chondro-sterno-costal tuberculosis and pulmonary tuberculosis.	....	Symptoms of purulent pleurisy.	Left base.	No signs of cavity.	.....	.....	Incision and resection of 6th rib in axillary line. Puncture, discharge of pus containing bacilli, lavage, drainage.	Death 1 month later,	.....	.....
1898 46	New York Med. News. D. Tait and Abrams, Feb. 26, 1878, p. 263.	M. 7 yrs.	Acute tuberculosis.	....	Previous croupous pneumonia, night sweats, progressive emaciation.	Lower lobe of left lung, upper portion.	.....	Adhesions present.	Puncture at lower dull area, negative, a 2d puncture at higher and deeper point revealed pus.	Pneumotomy, U-shaped incision 3½ inches between 7th and 8th ribs and anterior axillary and scapula lines resected, pleura opened. Pleural cavity shut off with gauze, lung incised with cautery to depth of 1 and 1½ inches, 75 cubic cm, of thick non-fetid pus escaped, opening enlarged and cavity swabbed and packed with gauze. Gauze removed from pleural cavity skin and muscle flap sutured.	Improvement, temperature lowered.	.....	.....

Cure maintained 1 year. Closure of cavity, relapse and reappearance of the signs of cavity in right apex. 2d operation, resection of 2d, 3d, 4th and 5th ribs. Pneumotomy, dressing compression. Death 28 days later from emphysema and accidents produced by the chloroform.

in the lower lobes are more easily drained, should give better results after drainage, and are more fatal when not drained than cavities in the upper lobes. The former points are emphasized by the case reported by N. Pendleton Dandridge[76] in his able article on the treatment of pulmonary cavities. While drainage of large tubercular cavities has not given satisfactory results as far as cure is concerned, I feel it is the surgeon's duty to resort to this operation very frequently as a palliative measure, as it relieves these great sufferers of their most distressing symptoms, viz.: cough and expectoration.

The following case illustrates the operation and course of cases after drainage of tubercular cavities:

J. M. C., aged 46, Cook County Infirmary, has been suffering from symptoms of tuberculosis for 10 months. He has emaciated to a great degree; has had severe night sweats, afternoon hectic flushes; he expectorates large quantities of purulent material with spasmodic attacks of coughing; one or two hours may pass without coughing, then he will get a severe spell and an ounce or more of pus will be expectorated, the odor of which is not particularly offensive. Examination reveals râles over upper lobe of right lung, extending down to the fourth rib; bronchial breathing, absence of normal respiratory sounds; a cavity can be located under the second rib, two inches to the right of the sternum, and extends from upper margin of the second to upper margin of the third rib; its transverse diameter appears to be about one and one-half inches.

Operation Dec. 12, 1897. It was decided to open and drain the cavity; a U-shaped incision was made extending from the first to the middle of the third rib, one inch to the right of the sternum. The incision was then curved upward and outward to the anterior axillary border; sub-periosteal resection of about three inches of the second and third ribs was made; the parietal pleura was separated from the chest wall to the extent of about an inch around the field of operation; the exploratory puncture was now made for the first time and pus withdrawn. A horizontal incision was made in the pleura over the center of the cavity; adhesions were present, and the incision continued about one and one-half inches in length, until the cavity was reached, which was opened at a depth of about one inch; the hemorrhage was not profuse, and was readily controlled by pressure; a digital examination of the cavity showed that it was about two inches in diameter with an irregular surface; it was packed with iodoform gauze; there were a number of smaller bronchietatic cavities opened in making the incision and a few caseous bronchial glands were removed from the mediastinal margin; the packing was re-

[76] Ann. Surgery, xix, p. 134.

moved in fifteen minutes; there was still some oozing, which was controlled by the Paquelin cautery. The cavity was repacked with iodoform gauze, and the flap was accurately sutured around the gauze drain; chloroform narcosis. The patient was not in the least shocked by the operation; the highest pulse rate following was 92; the temperature on the third day was 100.6 degrees; after the fifth day it did not exceed 99 degrees. He expectorated a bloody mucus for the first three days. He had no "fits of coughing" after the operation; the packing was removed on the fifth day and a soft rubber drain inserted; he was allowed to be up and about. There was a primary union of the flap except at the point of drainage. The drain was allowed to remain in for five weeks; it was then removed, as a fistulous canal had been established. His cough is reduced to a minimum, the discharge from the fistula is of a non-purulent mucous character, and while the fistulous opening is large the quantity of discharge is small. He has gained in weight, his night sweats have ceased, and his general condition is greatly improved. May 30, Dr. Johnson, Medical Director of the Infirmary, reports that the communication of the sinus with the cavity has closed, and that a small granulating surface remains at the external opening.

I have collected reports from the literature as follows: Tuberculosis of lung operated, 47; incision and drainage, 34; pneumectomy, 2; thoracoplasty, 5; puncture and drainage, 2; opening of superficial abcess, 4; recoveries, 26; recovery with fistula, 2; deaths, 19; 12 from undetermined causes; 1 multiple gangrenous foci; 1 acute miliary tuberculosis; 3 hemoptysis; 1 hemorrhage; 1 cachexia.

Pneumectomy for the removal of a part or a complete lobe of the lung for a tuberculous disease has been one of the triumphs of surgical technique, but so far the clinical results have been unsatisfactory. From the experiments of Gluck, Schmid, Bloch and Biondi,[77] we we were led to believe that pneumectomy as a curative method for tuberculous lesions of the lung would become an accepted surgical procedure; however, our hopes have not been realized. While the operation of removal of a complete lobe of a lung has been successfully performed the number of deaths following pneumectomy has been so large that the operation has been practically abandoned. The technique of pneumectomy will be given under the heading of Pneumectomy for Neoplasms.

Kronlein in 1884 operated on two cases of apical tuberculosis; one lived but a few hours after the operation, the other but a few days. Ruggi, 1885, opera-

77 Ber. Med. Woch., Vol. xviii, p. 645, 1881.

ted on two cases; one died on the ninth day from carbolic poisoning, and the other thirty-six hours after the operation. In 1891 Tuffier removed a small portion of the right apex through the intercostal space for tuberculosis; the patient made a good recovery and four years later was enjoying excellent health. In 1893 Mr. D. Lowson operated successfully on a woman 34 years of age for tubercular disease of the right apex. Doyen, 1895, also successfully removed a small portion of a lung for tuberculosis. Kronlein and Lowson give definite rules for the operation, the latter favoring the H or U-shaped incision, removing the second, third and fourth ribs from the sternum to the axillary line; this gives a large opening through which to work. After the chest has been opened the lung is to be drawn out, transfixed, ligated and amputated with the cautery. The cavity should then be drained and only partially closed. Tuffier in his operation deviated from this by producing an extra-pleural pneumothorax before opening the parietal pleura; he then divided the pleura and drew the diseased portion out through the opening. He closed the wound completely; his patient was about in twelve days. He places particular stress upon the advantage of preliminary extra-pleural pneumothorax. The pathologic conditions which render this operation necessary are such that at a time most favorable for the performance of the operation the patients will not submit, and when they desire the operation the pathologic changes are so far advanced that they are not in condition to withstand its severity. In one attempt at this operation adhesions were found so firm and resisting that the operation had to be abandoned. The dangers of separating an adherent apex on the mediastinal side should be borne in mind; 1, the mediastinal septum in front is thin and easily lacerated; 2, there is danger of tearing the azygos veins and the subclavian artery or vein at the extreme apex; 3, lower down there is danger of tearing the right cardiac auricle; this accident happened to me in an operation on the cadaver. When the lung is in an advanced stage of tuberculosis its infiltration is so extensive that it is not compressible, and estimates

on its removal must be based on the principles governing removal of a solid tumor of equal size. I have found when placing the forceps or ligature on the lungs of cadavers in this condition, that many times the tissue lacerated with the pressure. It must therefore be understood that the ligature must be placed on the base of the lobe, including only the arteries, veins and bronchi, and that the opening must be sufficiently large to admit of the extraction of a solid mass the size of the lobe to be removed. The removal of a complete lung for tuberculosis has not to my knowledge been attempted. In advanced tuberculosis the pathologic changes produce insurmountable barriers against the operation of pneumectomy, and while occasional success in partial resection may be achieved it can never become a practical method for the treatment of tuberculosis. I believe the trend of surgery in tuberculosis of the lung will be the utilization of surgical means for placing the lung in better condition for repair, as quiesence, compression, drainage, etc., rather than extirpation of the tubercular focus.

Hydatid cysts.—The surgery of hydatid disease of the lung is well established and exact lines are drawn as to its operative treatment. The results have been very flattering to the surgeon. It is variously estimated that from 11 to 16 per cent. of hydatids of the body occur either in the pleura or in the lung, these situations being the most frequent next to the liver. Many of the cases are secondary to disease of the liver, as the following case illustrates:

J. L., male, aged 46, came under my observation November, 1884. Six weeks previous he complained of a sudden pain in the right side, followed by dyspnea and a dry hacking cough; the distress was severe for three days; a diagnosis of pleurisy had been made and he was placed under medical treatment; when he presented himself at my office the following conditions were found: Respirations 36, temperature 99.2 degrees, pulse 110; he complained of great compression in the right side; dulness extended to the spine of the scapula behind and to the second interspace in front; respiratory sounds were absent; there was a bulging of the intercostal spaces and the apex beat was displaced one inch to the left; the liver margin extended one and one-half inches below the costal arch. The edge of the liver was soft and pliable and of regular anatomic formation.

Diagnosis.—Hydrothorax; aspiration of a large quantity of

clear fluid ; microscopic examination revealed hooklets. Patient had temporary relief, but in three weeks the distress was as great as before, when an operation was advised.

Operation.—Resection of two inches of the ninth rib in the anterior axillary line ; a large quantity of fluid escaped ; an opening in the diaphragm could be felt about two and one-half inches from the costal margin. A perforated drain was inserted through this opening and brought out through the chest wall. The patient improved rapidly in his general condition. Four weeks later there was a free discharge of bile through the tube. The pleural cavity rapidly contracted and at the end of three months there was nothing but a sinus into the liver, which was discharging bile freely ; the tube was removed in five months ; bile continued to discharge in enormous quantities ; the sinus closed nine months from the time of the operation ; the patient has remained well up to the present time.

In the United States hydatid is infrequent; it is often met with in the Canadian provinces and particularly among the Finlanders (A. H. Ferguson). The mortality from the disease treated medicinally or without treatment has been variously estimated; Niesser places it at 58.7 per cent; Devaine, $66\frac{2}{3}$ per cent.; Thomas, 54 per cent. The great majority of cases that recovered without surgical aid ruptured into the bronchi, and a few externally.

There are three methods of external treatment: 1, puncture; 2, free incision; 3, removal. Maydl collected sixteen cases treated by puncture, of which 69 per cent. died. The dangers of puncture are: 1, drowning during operation by opening into bronchus; 2, emphysema; 3, dyspnea from pneumo- and hydrothorax; 4, albuminous edema of the lung. The fatal accidents of puncture of hydatids must be borne in mind, and in hydrothorax when hydatid is even suspected exploratory puncture must not be performed; as an incision has no more dangers than puncture in simple hydrothorax and is so very much less dangerous in hydatid cyst, it should be adopted in place of puncture in doubtful cases. Puncture with canula is curative in only 25 per cent. (Tuffier); as the canula becomes occluded the multiple cysts are not drained, infection takes place and the incision will eventually have to be resorted to. Tuffier gives the immediate mortality of puncture with canula as 50 per cent. Thomas, 1885, gives the following comparison of results: Hydatids of the lung and pleura not inter-

fered with had a mortality of 54 per cent.; treated by puncture, 27 per cent.; treated by incision and resection, 16 per cent. Schwalbe (l. c.) states that hydatids of the lung without operation have a mortality of 60 per cent. Lopez collected thirty-six cases treated by pneumotomy; the mortality was 14 per cent.

Suppurating hydatids communicating with the bronchus, if not progressing favorably, should be treated as pulmonary abscesses, opened and drained, after fixation of the lung to the thoracic wall. Roswell Park collected thirty-two cases with four deaths, a mortality of 12.5 per cent. It is claimed by Tuffier that 90 per cent. of the cases recover after pneumotomy.

Tumors, from 1884 to 1896.

Case 1, 1884. Kronlein Berliner Clin. Chir. Woch., 1884, p. 199, and 1886, p. 185, Correspblatt Schweitzer Aerzte 1887, xvii, p. 696, et in Mueller Deutsche Zeith. für Chirurg., 1893, Vol. 67, p. 41. Female, 18 years. Diagnosis: sarcoma of lung secondary to costal sarcoma of eight months' standing, in sixth rib, left axillary line. Operation in thorax pleura: incision from second to fifth rib, resection of thoracic wall, fifth, sixth, seventh and eighth ribs being found adherent to tumor; once adhesions are separated there is produced an alarming thorax; anesthetic had to be stopped. Operation on lung extirpatory of secondary sarcomatous nodule the size of a walnut; resection done in healthy pulmonary tissue, lung sutured with catgut, drainage of pleural cavity; recovery without incidents. Results: recurrence without scar three years and three months after extirpation and pneumectomy, recurrence six months after in thoracic wall, new operation but no pneumectomy; died seven years after first operation; general metastasis.

Case 2, 1887. Sedelot, quot. Baldus in 1887, Bown, p. 16, et Par. Mayermang, dissetato, 1889, p. 13. Diagnosis: sarcoma of lung secondary to sarcoma of thoracic wall. Operation in thorax pleura: resection of two ribs and all of thoracic wall, including pleura. Operation on lung: resection of portion of lung adherent to thoracic wall. Recovery.

Case 3, 1893. Mueller, Deutsche Zeitsch. für Chirurg., 1893, Vol. 37, p. 42, Male. Diagnosis: chondromo of lung secondary to costal osteo-sarcoma. four years; base of right lung and anterior portion of thorax from sixth to seventh ribs and from sternum to axillary line. Operation in thorax pleura: resection of thoracic wall from third to sixth ribs, inclusive, adhesions of lung to pleura being separated there is produced a complete pneumothorax with cessation of respiration; these symptoms ceased on lung being drawn to thoracic wound. Operation on lung: extirpation of neoplastic nodule, double ligature of pulmonary pedicle and suture of lung wound, which measures 9 by 13 cm.; drainage of pleural cavity. Rapid recovery in three weeks; superficial recurrence in scar two years and three months after extirpation; patient is still cured, four years and eight months after first operation.

Case 4, 1894. Weinlechner in Mueller Deutsche Chirghief., xl, 2, p. 269, in Mueller Deutsche Zeitsch. Chirurg., 1895, xlvii, p. 41. Diagnosis: myxocongroma of lung second to myxocongroma of thoracic wall. Operation in thorax pleura: resection of three ribs and of all thoracic walls, including pleura, resection of portion of lung as large as the palm of the hand adherent to tumor, resection of two pulmonary metastatic nodules in inferior lobe. Death twenty-four hours after. Necropsy: purulent pleurisy, excision of thoracic walls had not allowed union of soft parts.

Case 5, 1896. Koenig, Berlin Woch., 1896, p. 132. Diagnosis: sarcomatous nodule secondary to sarcoma of sternum. Operation on thorax pleura: resection of sternum. Operation on lung: resection of small sarcomatous nodule without suturing pulmonary wound. Died on night following operation of a pneumothorax.

Case 6, 1896. Williams, quot. by Zegari, p. 143. Male, 37 years. Diagnosis. myxocondroma of median lobe of right lung, secondary tube costal myxocondroma; duration four years; from second to seventh ribs in neighborhood of nipple. Operation in thorax pleura: resection of thorax of third, fourth and fifth ribs, pneumothorax, collapse of lung. Operation on lung: resection of a voluminous nodule of small volume in superior lobe; death due to collapse.

Actinomycosis of the lung.—Actinomycosis of the respiratory organs is next in frequency to actinomycosis of the digestive tract. It may appear as a primary lesion of the lung, or the lung may be secondarily attacked from an actinomycosis of the bony framework of the chest or from an actinomycosis penetrating the diaphragm. A detail of the history of the disease, while it might be very interesting, will not be considered here. Langenbeck in 1845 first described the disease. Ponfick, Israel and Bollinger made a very extensive study of the subject. Israel collected nine cases of actinomycosis of the air passages. When it occurs primarily in the lung it may have been inhaled. When the lung is infected the tendency is to a rapid infiltration and extension of the disease. It is not so likely to be overlooked now as in former years; the sputum of every patient with chronic pulmonary lesions is repeatedly examined, and while the ray fungi are not sought, they are not often overlooked. The medical treatment of actinomycosis is becoming more satisfactory as time advances; iodid of potassium has proved most useful. We find in the literature a number of cases in which it was used with curative effect; it should be administered in increasing doses until iodism is produced. This is now being supplemented by the internal use and external application of nitrate of silver, suggested by Dr. Poore (Paget). He bases his recommendation on his experience in one case of actinomycosis of the right pleura and the specific fatal effect of nitrate of silver upon the aspergillus niger noted by Raullins; one part in a million and a half in culture media would prohibit the growth of the latter. When the lung is infected with actinomycosis it produces no specific symptoms in its early stage; later the chest wall is attacked and external sinuses may develop, when the true character of the lung lesion can be readily recognized if it has not already been detected in the sputum. If treated surgically the indication is a radical extirpation of the

disease; if this can not be accomplished, careful and thorough curettement and packing with a nitrate of silver gauze is indicated. Godlee favors radical surgical treatment when iodid of potassium has failed, and while I agree with him in this *dernier ressort*, from my experience with surgical treatment of actinomycosis in other parts of the body, I would consider that the lung is a very unpromising field for surgical treatment. A very interesting case was reported by Dr. Karewski at the recent meeting of the Berlin Medical Society.[78] Fraenkel made the diagnosis from the physical appearance without the aid of the microscope; extensive resection of the ribs and chest wall was made; the patient recovered and only a small sinus remained.

Dermoid cysts will not be considered in this article, as they are always mediastinal tumors and not true tumors of the lung, although they frequently rupture into the trachea or bronchi and their contents are expectorated (see Clotta's case, also a very interesting case reported by Dr. Ogle;[79] another by Rickman J. Godlee).[80] These tumors are all of mediastinal origin (Bland Sutton).

Neoplasms of the chest wall and lung requiring pneumectomy.—Of the neoplasms occurring primarily in the chest wall and involving secondarily the pleura and lung we may mention, 1, the sarcomata of the ribs and sternum; 2, the enchondromata (varieties); 3, the carcinomata, occurring first in the mammary gland and involving the muscle, bone and pleura of the chest wall by continuity of the process or by secondary glandular infection. The following tumors in the lungs are pathologic curiosities: Fibromata, lipomata, angiomata, dermoids (Clotta) and gummata of the chest wall. When these neoplasms invade the pleura, adhesions are not infrequently formed; the lung may also be involved at the time of operation, necessitating excision of a greater or lesser portion of it with the tumor. Primary malignant neoplasms of the lung are rare; secondary involvement of the lung

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78 Allgem. Med. Centr. Zeit., Vol xxiii, xxiv, p. 298.
79 Medical Week, Paris, March 5, 1897, p. 101.
80 Ibid.

by carcinoma and sarcoma is not uncommon. Wilson Fox, who collected 112 cases of tumors, showed that the disease was primary in 38, secondary in 64 and indetermined in 10. Primary cancerous growths usually originate in the mucous glands, and as these are lined with cylinder cells they are frequently cylindrical epithelioma. An alveolus may be the initial seat of the disease. Primary sarcoma may occur in the lung and is usually of the round-celled variety; spindle-celled and myeloid growths have been observed; they very closely resemble aneurysm and the greatest care must be exercised in making a differential diagnosis. In many cases it is difficult to say whether the malignant disease is primary or secondary in the lung; the surgeon is rarely called upon to operate on these cases, as they are not diagnosed. The class of malignant disorders of the lung which comes to the surgeon for operation is that in which the disease is secondary to disease of the chest wall. This leads us to the consideration of the subject of pneumectomy in general.

Pneumectomy was performed first for the cure of hernia of the lung; one case was published by Rolandus, 1492. The cases of amputation of a protruding lung do not clinically come under the heading of pneumectomy, as they do not involve the dangers and difficulties of technique associated with intra-thoracic pneumectomy. The first pneumectomy was made by Péan in 1861; he was resecting a tumor involving the third, fourth and fifth ribs; the pleural cavity was opened, the ribs mentioned excised and the lung was found adherent and involved in the tumor. The visceral and parietal pleuræ were sutured and the Paquelin cautery was used to remove the diseased portion of the lung. The first scientific experimental investigation was made by Gluck, 1881 (l. c.). He performed pneumectomy on 6 dogs and 14 rabbits; two of the latter lived for three months; all of the dogs died; in one, in which he ligated the stump of the lung without a pneumectomy, he found that the portion of the lung on the distal side of the ligature did not mummify, but lived. There was primary union of the vessels. There was always immediate cyanosis

after the operation. He arrived at the following conclusions: Ligature with pneumectomy is tolerated well by rabbits; if the operation be aseptically and well performed recovery is permanent; primary adhesion of vessels takes place; no cardiac thrombosis; the stump lives and forms part of the cicatrix; the fatality is caused by pneumothorax, pericarditis, infective pleurisy of the same and opposite sides. Milton Antony[81] of Augusta, Ga., reports that in 1821 he was called to a patient in the western frontier suffering from a growth of the lung pressing out the fifth and sixth ribs. He made a resection of these, scooped out the degenerated tissue or tumor of the lung and plugged the cavity; the patient recovered. While this case antedates Péan's it should not be considered a pneumectomy. From his report there is some doubt that any lung tissue was removed, as the patient had no cough nor expectoration and there was no mention made of air escaping through the wound. Be that as it may, he deserves credit for having suggested and practiced sub-periosteal resection of the rib to allow the wall of the chest to fall in and fill the space; an operation which subsequently added much to the fame of Estlander and Schéde. Marcus, in 1881, removed one entire lung from two dogs and three rabbits. One dog died from the anesthetic, the other from purulent pleurisy; the rabbits died on the third, sixth and twenty-seventh days respectively. These experiments were rapidly followed by those of Hans Schmid,[82] which were made independent of a knowledge of Gluck's. He used morphin and ether for narcosis; hemostasis of the excised portion was secured by transfixion and ligation with catgut; he made exact suture of the edges. In eight partial resections in dogs there were five deaths and three recoveries; the deaths were caused in four by suppurative pleuritis, in one by carbolic acid poisoning. In partial resections a V-shaped incision was made with accurate suture of edge. He removed both apices successfully in the same dog, six weeks intervening between the operations; there was no secondary hem-

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81 Phil. Med. Jour. 1823, p. 108.

82 Berlin. Med. Woch., No. 57, Dec., 1881.

orrhage; he expressed the belief that partial excision was applicable to local tuberculosis, injuries, abscesses and tumors of the lung and rib.

In May, 1881, Bloch performed nine experiments for the removal of the lung on five rabbits and four dogs; all of the former died immediately after the operation; one of the latter lived fourteen days; the other dogs all died shortly after the operation. In July, 1881, he performed sixteen experiments with resection of the rib on rabbits; all died a few days after from hemorrhagic pleurisy; the time required for operation was forty-five minutes. He changed his method to an intercostal incision with the removal of single lobes and reduced his time to ten minutes. With this method two dogs recovered, one from a lower and the other from a middle lobe amputation; when the dogs were killed no pneumothorax, exudate, nor displacement of organs was found. He noted the anatomic communications of both pleural cavities in some dogs; all with this communication terminated fatally; he advised against drainage. He removed infiltrated lobes through intercostal spaces and favored that plan very much.[83] Bloch's experiments were very discouraging, but the profession was soon relieved from their depressing effect by the more extensive, scientific and fruitful researches of Biondi which carried the profession too far in the opposite direction. In 1882 Biondi made the following experiments: Extirpation of right lung, healthy animals, 23 experiments, 12 recoveries; extirpation of left lung, healthy animals, 34, 18 recoveries; extirpation of both apices, 3 experiments, 3 recoveries; middle lobe, 1, 1 recovery.[84] His experiments were exact as to details and his results were the best obtained. He found that the great majority of animals infected artificially with tuberculosis in the lung and not treated died of the tuberculosis; on the other hand, he found that a timely resection of the apex of the lung saved a goodly number. The success of these experiments stimulated surgeons to operations for removal of the lung. Zakharwitch made a minute study of the technique of these

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83 Deutsch. Med. Woch., Berlin, 1881, vii, p. 634.

84 Gior. Internaz. d. So. Med., Napoli, 1882, N. S. iv, 759-1883; N. S.

operations experimentally on cadavers and on animals. His results almost equalled those of Biondi. He laid down definite rules for pneumectomy. W. LeMoyne Wills[83] reports some very interesting and instructive experiments of pneumotomy and pneumectomy.

Weinlechner, in 1882, removed three ribs for malignant disease and excised two nodules from the lung; the opening in the pleura was so large that he found it impossible to obtain a sufficient flap to cover it; closed with packing; patient died in twenty-four hours from acute pleuritis.

Kroenlein, in 1884, operated on two cases; one ended fatally a few hours after operation and the other lived but a few days. Ruggi, in 1885, performed two operations; in one he succeeded in removing the apex, and the patient died on the ninth day from carbolic acid poisoning; in the other he found it impossible to detach the lung from the pleura; the patient died thirty-six hours after the attempt.

Sedillot, in 1887, removed a portion of a lung which was adherent to and involved in a sarcoma of the chest wall. Patient recovered. W. Miller, 1888, removed a portion of lung and chest wall successfully for enchondroma.

In 1891 Tuffier removed successfully a tubercular nodule from the apex of the right lung. He first separated the parietal pleura from the ribs all around the field of operation; when this was accomplished he palpated the tumor, divided the pleura, grasped the lung with the forceps and drew it out through the slit in the pleura, producing a hernia of the lung. A tubercular nodule the size of a hazel-nut was excised and the lung was allowed to drop back. The incision was completely closed; the patient was reported well four years later. This was certainly an ideal case for excision.

D. Lowson, 1893, excised the apex of the right lung for tuberculosis. He made an angular incision and resected the second and third ribs. A small opening was made in the pleura; he filled the pleural cavity with sterilized air to force collapse of the lung. This caused no dyspnea or cyanosis: he then opened the

[83] Southern Calif. Prac., Los Angeles; 1892, vii, 167.

pleura, freed the adhesions and brought the lung out through the fissure, transfixed it, ligated and exsected the infiltrated portion; he replaced the lung and closed the chest cavity without drain. It had to be opened two weeks later for the removal of some pus and blood; the patient was discharged from the hospital in eighty days; she had gained rapidly in flesh and the wall was closed to a small sinus. This operation shows the most praiseworthy preparation and execution, and the result was well deserved.

These operations were rapidly followed by those of Miller, Kœnig, Mikulicz, Albert, Tillmanns and others; but the hope of success that was born from the results of Biondi's experiments has never been realized. In 1887 Roswell Park, in an able article, reviewed the cases treated up to that time. E. Willys Andrews[86] advocates removal of upper lobe of lung, and has confidence in its success; he emphasizes the dangers and difficulties caused by adhesions; he believes large incision in the axillary line is most advantageous for operation. Pneumectomy for primary tumor of the lung has never been performed. Schlepfer collected 16 cases of enchondroma in which the chest was opened, with 8 recoveries and 8 deaths. Tillmanns considers that the greatest danger in the removal of these tumors is in the opening of the pleura and mediastinum; not from the pneumothorax but from the infection of the pleura. Terrier advises the free opening of the pleura, regardless of the pneumothorax, for the excision of these tumors. For hernia he favors the reduction without rib resection.

My experiments were made to familiarize myself with the technique and feasibility of the various operations; the manipulation and exposure for observation of certain phenomena were excessive and were not conducive to the recovery of the animals. The following is the report on pneumectomy:

Experiment 2.—Oct. 24, 1897; small brown dog; ether anesthesia; the same antiseptic precautions were used as in experiment 1. Osteoplastic resection of fourth and fifth ribs of right side was made; parietal pleura retained on flap; action of mediastinal septum observed as in experiment 1. Lower lobe of right lung was brought out through and plugged the open-

86 Chicago Med. Recorder, 1892, p. 537.

ing; this relieved all respiratory difficulty; the lobe was transfixed, ligated with heavy silk and two-thirds of the lobe excised; there was no hemorrhage and the lung was returned; a subcutaneous buried suture of catgut entirely closed the wound; time consumed in operation, twenty-one minutes. By a mistake in orders the dog received nothing but water for three days; when the error was discovered he was very weak; he died on October 29, five days after the operation.

Postmortem.—Perfect primary healing of external wound had taken place; there was a slight edema of deep tissues; periosteal flap in good position; on opening the pleural cavity the lung was found to be entirely free from adhesions; the pleural cavity contained no pus or serous fluid; the ligature was in position; pressure necrosis had liberated a small portion of the lung on the side nearest the base; there was no odor from the stump; the remaining one-third of the lobe was normal; there was no pneumonic infiltration; thrombosis had not advanced in the ligated arteries or veins; the bronchi were closed; there was no pericarditis or pleuritis on the opposite side; there was no pathologic cause of death and it was probably due to the error in orders mentioned.

Experiment 3.—Oct. 24, 1897; small black dog; ether anesthesia; an osteoplastic flap of second and third ribs on right side was made; movements of mediastinal septum observed as in previous experiments; the septum was thicker than in the last dog; there was marked cyanosis after opening the pleura; when the hilum of the lung was grasped with forceps so as to prevent the vibration of the septum respirations were rapid, but the cyanosis and collapse disappeared; the upper lobe was drawn out through the opening and ligated at the hilum en masse with silk ligature; the wound was closed with catgut as before; time consumed in operation, sixteen minutes. The dog left the operating table in good condition but became quite sick the same evening, and continued so until death forty-eight hours after operation.

Postmortem.—Accumulation of pus present between skin and osteoplastic flap; the latter was held fairly well in position by sutures; the pleural cavity was found full of sero purulent fluid; numerous adhesions had formed between the diaphragm and the parietal wall; the lower lobe was partially consolidated with pneumonia; ligature was buried in exudation; pleuritis on left side; pericardium free from inflammation.

Experiment 4.—Nov. 8, 1897; small black dog, weight about thirty-eight pounds. A U-shaped incision with resection of one and one-half inches of the fourth rib on right side was made; osteoplastic flap; the lung was immediately drawn out and three lobes ligated at hilum with catgut without transfixion. The opening in the chest was closed by a deep catgut suture and a continuous silkworm-gut cutaneous suture; time for operation, twelve minutes; November 9 dog in good condition; November 10 dog in good condition, wound looks well; November 11 dog playful but breathing rapidly; November 12 dog in excellent condition; the silkworm-gut suture had been bitten out and there was a slight gaping of the flap; air entered

and escaped through the skin wound in small quantity; it is believed that this passed in and out of a subcutaneous cavity only and that the pleura was still closed; November 20, dog in good condition, external wound almost closed; no air passing through the opening; the dog became fat and appeared to suffer no discomfort except a slight increase in frequency of respirations; he was killed on March 14, eighteen weeks after the operation.



Fig. 20a.—Shows empyemic cavity after partial contraction has taken place following drainage.

Postmortem.—A heavy clamp was placed on the trachea to prevent collapse of the lung when the chest was opened; the organs were thus retained in the same position as during life; the external wound had cicatrized and contracted; there was a defect in the bony thoracic wall about one inch in diameter where the rib had been resected; the edges of this defect were covered with shreds of connective tissue. the ends of the rib were smooth and covered with connective tissue. The thyroid

gland was much enlarged; the right pleural cavity was small and had in it a few drams of serous fluid; the heart and mediastinal contents were displaced markedly to the right; the delicate mediastinal septum was intact; the pulmonary stump could not be recognized; a mass of connective tissue, firm and glistening, about the size of a hen's egg, occupied its supposed location. Shreds of adhesive bands existed between the diaphragm and chest wall; a few vascular villous shreds projected from the pleural surfaces in various places; the left pleura was smooth and non-adherent; pericardium was normal. The esophagus, larynx, thyroid, trachea, heart, entire left lung, the lower lobe of the right, the anterior thoracic wall and the diaphragm were removed en masse and submitted to Dr. W. A. Evans for pathologic examination, report of which is as follows: The right side of the diaphragm was elevated and attached to the mediastinum and the chest wall. A line drawn through the center of the trachea and continued downward passes through the center of the heart, cleaving its tip exactly in the middle. The entire heart had been drawn to the right, but the most marked displacement was in the swinging of the tip with the base fixed. The sternum was bent to the right, as shown in the diagram (Fig. 20 b.) outlines for which were measured. The bend was most marked at the fourth rib. Two cm. to the right of the sternum and 13 cm. above its tip is an opening 4.5 cm. long, by 2 cm. wide. This opening is covered by a flap in which is a piece of rib 2.5 cm. long; this piece is entirely separated from other bony structure. The space between the ragged ends of the rib and this piece is scant 3 cm.; all of the surfaces of these pieces show slight nodular periosteal thickening. The soft tissue flap which contains this piece of bone bellows out into a hernial sac, measuring approximately 5 cm. across and 4 cm. in height. Its internal surface is smooth and glistening except for bands of yellow-colored fibrous tissue which run here and there; these blend into the connective tissue of the wall.

Left lung: The lowest lobe is large, fully expanded and has no adhesions to the wall; the middle lobe also no adhesions to the wall; these two lobes are bound together by firm adhesions. Upper lobe; this measures 6x4½x4 cm., is heart-shaped, and is covered by firm, thick pleura .8 to .5 cm. in thickness. The pleura has a smooth glistening surface. There are no pleuritic adhesions. The bands of fibrous tissue in this lung run parallel to its surface. The outer layers of the pleura are the densest. The upper lobe of the lung is not attached to the others. The appearance of this lobe is that of a cyst. The bronchial tubes are patulous to the smallest. The lung substance is firmly compressed.

Right lung: *The upper lobes* of this lung are gone. A stump containing a small amount of lung is to be seen. (See Figs. 21 and 22). This was excised for microscopic examination. The lower lobe has attachments to the diaphragm which are hard and ligamentous. Its attachments to the pericardium and to the mediastinum are equally as firm. The pleura measures .3 to .5 cm. in thickness, and is firm and dense on its outer

surface; is free except at the attachments noted. On incision the lung substance is firmly compressed and the bronchioles are patulous.

Microscopic examination of the stump of the upper lobe shows the following: The end of the bronchus is plugged

Fig. 20b.—Deviation curve in sternum, Experiment 4.

with fibrous tissue, the bands of which run in every direction. In this mass of tissue are a few bronchial glands. Besides this there is no trace of epithelium. The connective tissue has grown from the mucosa and the inner fibrous coat. The islands of cartilage run in every direction, but the general dis-

position is to form a triangle. The cartilage plates do not show degeneration phenomena. The vessel wall interior to the inner elastic lamina is thicker than the balance of the wall. The fibers of the wall all run in the same direction. The blood vessels are closed by growths of connective tissue which are mostly inside of the inner elastic lamina. Sections from higher up in the bronchial tree show a small lumen with the mucosa thrown into the usual folds. The epithelium is falling away and much of it is loose in the lumen.

This detailed report is submitted to show the histology of the closure of the vessels and bronchus of the stump; it will be noted that this dog had three lobes in his left lung, and while we had removed three on the right side there was still another left, showing an anomaly of development. Quénu observed that the dog's lung is occasionally divided into as many as six distinct lobes by fissures extending to the hilum.

Experiment 5.—Nov. 8, 1897; large black and white dog: thorax opened on right side, as in previous operations; the mediastinum ruptured and the dog ceased to breathe; after the lungs had collapsed the chest was compressed and the aperture closed with the hand; then the dog began to breathe but with considerable difficulty; on account of rupture of the mediastinum no further attempt was made at operation; the chest was compressed and the muscular flap rapidly closed over the opening with a firm catgut suture and buried catgut subcutaneous suture. November 9, dog in fair condition; November 10, dog sick, breathing rapidly; November 11, dog died.

Postmortem—incision in chest wall adhered per primum; right lung was collapsed; left lung was dilated apparently to normal size; it was slightly emphysematous; there were a number of hemorrhagic patches in the lower lobe; no evidence of hemorrhage or suppuration; cause of death could not be ascertained, but I believe it was due to the rupture of the mediastinum, which impaired his respiration after the closure of the chest.

Experiment 6.—Nov. 25, 1887; large white bull dog; there was the usual preparation and anesthetic; incision was made the same as in previous experiments; the entire right lung was drawn out through the opening; there was considerable pressure on the hilum to produce this result; a catgut ligature was thrown completely around the hilum; the lung was excised and the stump sutured with catgut in the opening close to the sternal border; there was considerable tension on the stump; time of operation, twenty-minutes. I had hoped by this method to produce an extra-pleural treatment of the stump, but in the dog I could not use the hysterectomy retention needles to hold the stump extra-thoracic; the external wound was closed with buried catgut suture; November 26, dog was very sick; on the morning of the 27th he was found dead.

Postmortem—Incision firmly agglutinated; the stump of lung was found partially adherent in the incision; there was some blood in the pleural cavity, and a septic pleuritis on

both sides; the catgut ligature on the stump had given way.

The difficulty encountered in this case in drawing the stump of the lung forward for extra-pleural treatment should not be experienced in the human, as the longest diameter in the dog is the antero-posterior, while in the human it is the shortest. In the cadaver I found it easy to draw the lung out through an opening on the side of the sternum, and believe that in pneumectomy the stump can be treated in this position; it appears from the results in pneumectomy for pulmonary hernia that this treatment of the stump will be the most favorable.

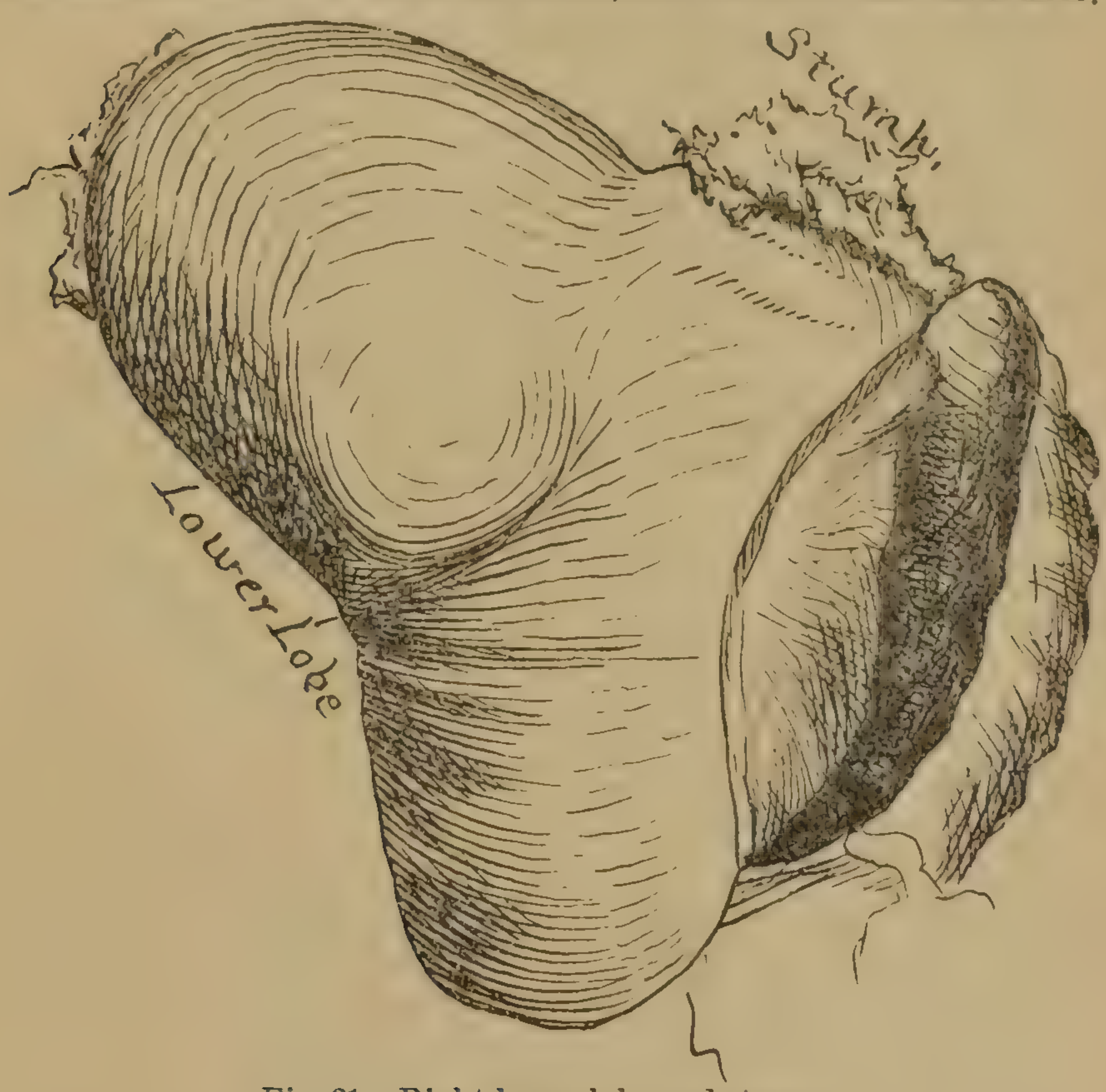


Fig. 21.—Right lower lobe and stump.

Experiment 7.—Nov. 25, 1897; small black dog; resection of third rib, right side; osteoplastic flap was made; ligation of the hilum of the entire lung above the bifurcation of the large bronchus; stump top sewed. I endeavored to secure a pleuritic flap from the mediastinum and chest wall to cover the stump, but did not succeed; the chest was closed as in previous cases; an aspirating needle was then inserted into the right side and the air in the chest cavity pumped out for the purpose of drawing the mediastinal septum to the side operated, and assisting the expansion of the left lung; this improved the dog's respiration materially; time consumed in operation, thirty minutes; the dog when removed from the table was in poor condition; November 26, dog improving;

November 27, in fair condition; November 28, not so well; drowsy; November 29, very sick; November 30, dog died.

Postmortem.—Incision healed per primum; when the pleural cavity was opened air entered with considerable force; there was no bad odor; point of ligation presented a hard nodule of granulation tissue which seemed to be aseptic; the bronchus was closed; left pleural cavity normal; pericardium normal; examination of specimen showed closure of artery and vein with small clot near point of ligature; mucous surface of bronchus granulating; cartilage unchanged; cause of death not ascertained.

Experiment 8.—March 26, 1898; large female dog; an osteoplastic flap of second and third ribs was made; two upper lobes of right lung were ligated at base with chromicized catgut and excised; the stump was covered by suturing the base of the lower lobe over with chromicized catgut to form a cap; this left no abraded surface within the pleura; the dog died on the third day.

Postmortem was made fifteen hours after death; external wound found clean; there was emphysema of chest wall in neighborhood of wound with slight discharge of sero-sanguinous fluid through deep line of sutures; right pleural cavity contained about 500 c.c. of fluid blood with few coagula which were adherent to the stump; the stump was found in good condition, the lower lobe covering about two-thirds of it; the ligatures were in position; the entire parietal and the remaining portion of the visceral pleuræ were covered with a thick, hemorrhagic membrane; when this was peeled off the underlying pleura was injected but smooth and glossy; heart normal; pericardium and pleura of opposite side normal. Cause of death, septic pleuritis.

Experiment 9.—April 24; large female dog, 45 pounds; ether anesthesia; an osteoplastic flap of four inches of fifth rib (right) was elevated. This rib I find is the best to resect in dogs, as it permits easy access to the hilum of the lung; on the admission of air respiration ceased; the thin mediastinal septum flapped to and fro and soon became emphysematous from the admission of air between its layers; for two minutes the respiratory efforts continued and then suddenly subsided; the heart continued its regular action; the right lung collapsed, contracted around its hilum and the diaphragm receded; the entire lung was grasped with the fingers and drawn out through the opening: as soon as it plugged the orifice the dog began a rapid gasping respiratory movement which soon became regular and full; the upper and middle lobes were separated from the lower, ligated at the base with chromicised catgut and excised; with three continuous catgut stitches the base of the remaining lobe was sewed over the stump of the excised lobes, forming a cap or covering; the stump was allowed to recede into the chest; there was no hemorrhage; the mediastinal septum was now very emphysematous and bulged greatly to the left side; the left lung could be seen through the delicate septum; a deep row of catgut sutures approximated the muscle wall and pleura and a superficial buried subdermal catgut

suture approximated the skin; I used the buried suture as I found it would materially lessen the danger of superficial wound infection; an aspirating needle was then introduced into the fourth interspace and the air aspirated from the right side; this

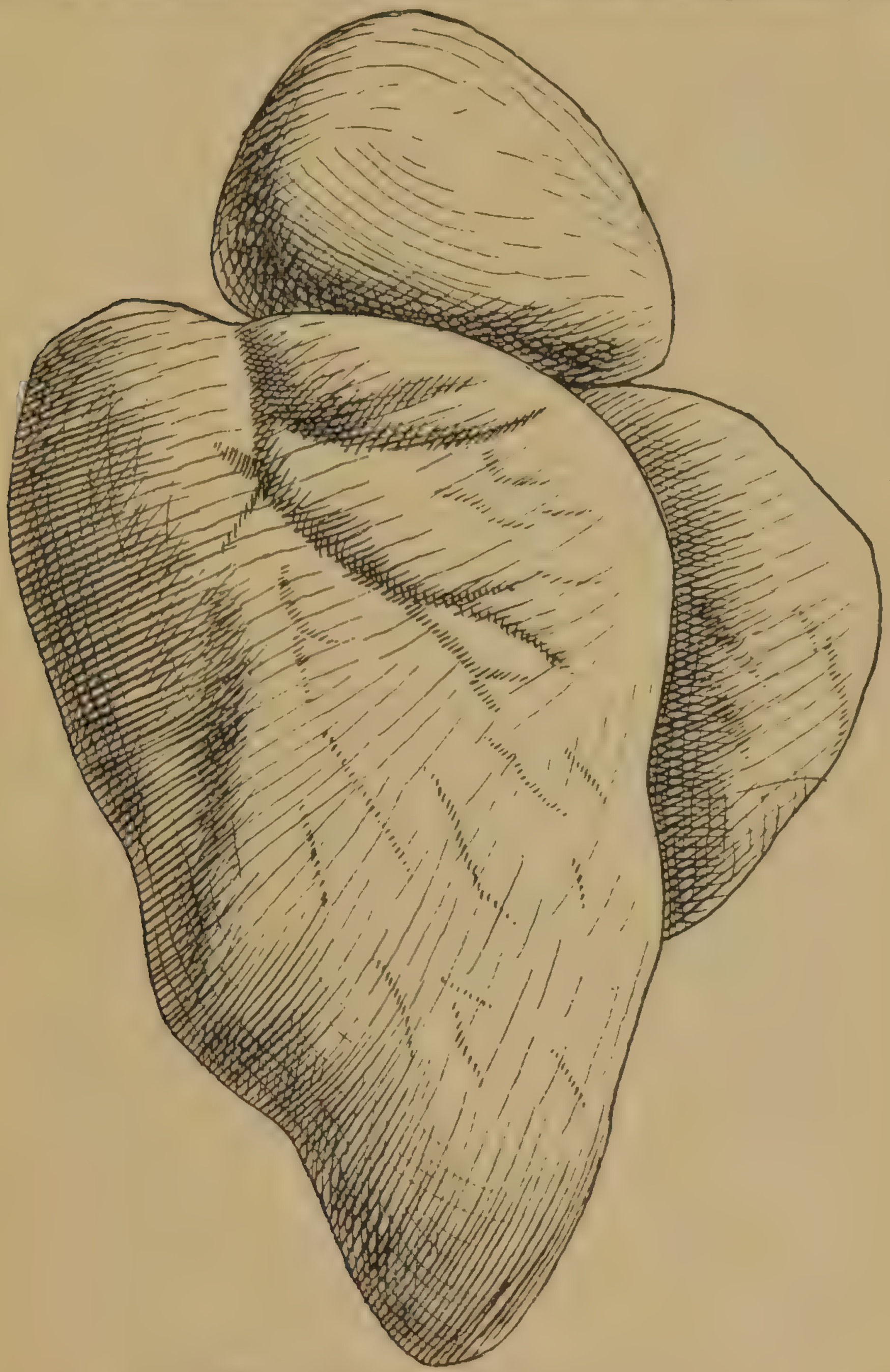


Fig. 22.—Posterior view of lobe and stump.

was for the purpose of re-expanding the lower lobe of the right lung and putting the mediastinal septum on tension so as to aid the respiration of the left lung. April 25, the dog had been very quiet and apparently comfortable; she took her food freely this morning; her respirations were, however, rapid; in the

evening her respirations were still more rapid but she partook of food; April 26, dog panting and very sick; died at 9 o'clock A.M.

Postmortem.—There was primary adhesion of skin and muscle; when the chest wall was opened there was neither entrance nor exit of air; thirty-four ounces of fluid, sero-sanguinolent, flowed out of the wound; on the left side there was a sero-purulent pleurisy with edema of the lung; the lung was greatly compressed; the mediastinal septum bulged far to the left of the median line; the right pleura was covered with a fibrinous exudate about one-eighth of an inch in thickness; it was divided into many compartments by trabeculæ of this material extending from the mediastinal septum to the chest wall; lower lobe of right lung collapsed and hidden from view by the fibrinous exudate; the stump was completely covered by the adherent lobe; the death was caused by the large accumulation of fluid shutting off her respiration, there had been no hemorrhage.

Experiment 10.—May 1, 1898; large male dog difficult to anesthetize; when finally overcome was very cyanotic; respired feebly; when the chest was opened respiration ceased; artificial respiration resorted to with no effect; the heart ceased to beat; tracheotomy was then performed and a rubber drainage tube inserted into the trachea; the upper air passages were closed; the lung could be easily made to expand and protrude many inches through the opening, illustrating beautifully the practical application of Tuffier's method of artificial respiration; it was however too late for restoration.

It was my intention before publishing these experiments to produce a number of herniæ of the lung subcutaneously and later amputate the protruding portions, but time did not permit. This should from clinical experience, be the most favorable method of pneumectomy as Coubey collected fourteen cases of hernia treated by pneumectomy, with twelve recoveries.

I wish to express my appreciation and thanks to Drs. W. A. Evans and George W. Johnson for the assistance rendered me in this work.

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Right Side

Face down.

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FOR MEDICAL DIAGNOS[illegible]

W. C. BUCKEL, Manager.

TEL. 2018, [illegible]

INSPIRATION

J.E Nudeaif May 8 1915

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RADIOGRAPH No. 2 (X



— EXPIRATION —

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down.

EXPIRATION

J. L. Black Aug 1925

Explosives 1st aid

Card: Dr. J. B. Murphy.



Right Side.


Left
Roentgen X Ray
FOR MEDICAL DIAGNOSIS



Right

Watson Wiley Laboratory

Elsie Park.


Fuel Tank
Fuel Tank

Roentgen X Ray Laboratory

FOR MEDICAL DIAGNOSIS

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RADIOGRAPH NO. 10—CA

SE OF DR. J. B. MURPHY.



Ed. Dayton.
May 19th 1915
Back - Front View.
Case Dr. J. B. Murphy.

RADIOGRAPH NO. II—C



Right Side.

E OF DR. J. B. MURPHY

H. A Edwards.
Back - Front View.
May 17th 1898
Case Dr. J. B Murphy.

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